State of California
The Resources Agency
Department of Water Resources

FINAL REPORT
COMPARISON OF FISH DISTRIBUTION TO FISH HABITAT IN THE LOWER FEATHER RIVER
SP-F3.2 TASK 1, 4, 5

Oroville Facilities Relicensing
FERC Project No. 2100

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REPORT SUMMARY

The purpose of SP-F3.2 Task 1 is to document the distribution of non-salmonid fish species in the lower Feather River from the Thermalito Diversion Dam to the confluence of the Sacramento and Feather Rivers. The purpose of SP-F3.2 Task 4 is to identify fish habitat in the lower Feather River as it pertains to species-specific habitat requirements, and the purpose of SP-F3.2 Task 5 is to evaluate potential project effects on non-salmonid fish species, and to integrate fish species distribution information and habitat requirements.

To complete Tasks 1, 4, and 5 of SP-F3.2, fish species distribution and species-specific habitat component information were analyzed. Fish species distribution information was developed utilizing three distinctly different collection methods including snorkel surveys, rotary screw trapping, and seine surveys. Fish habitat quality, quantity, and distribution are defined through the presence or absence of combinations of specific fish habitat components that are required by each fish species. Fish habitat components characterized in the lower Feather River included mesohabitat type, substrate, water depth, instream cover complexity, water temperature and dissolved oxygen concentration.

Three hundred seven mesohabitat units were identified in the Feather River, from the Thermalito Diversion Dam to the confluence with the Sacramento River. Mesohabitat units ranged in size from approximately 0.01 acres (535 ft^2) to 708 acres and were classified as backwater, pool, glide, run, boulder run, or riffle habitat. Substrate, depth, and instream cover complexity were characterized in each of the mesohabitat units. In general, mesohabitat type diversity decreased from the upstream to downstream portions of the lower Feather River, the proportion of fine substrates increased with distance downstream, intermediate depth classes occurred more frequently downstream along with the greatest proportion of deep pools in the most upstream portions of the lower Feather River, and instream cover complexity increased with distance downstream.

Water temperatures were recorded at 24 thermograph locations within the lower Feather River approximately every fifteen minutes between January 2002 and December 2003 from which the mean daily water temperature was calculated. The lowest and highest recorded mean daily temperatures were 45.5°F (7.5°C) and 75.9° F (24.4°C), respectively. Water temperatures tended to be coldest in the upper portions of the lower Feather River near the Fish Barrier Dam and warm progressively downstream during the spring, summer, and fall.

Dissolved oxygen (DO) concentrations were collected in 19 pools in the lower Feather River during 2002. None of the samples collected in the lower Feather River had DO concentrations less than 6.5 mg/L.

Water quality samples were collected at 17 locations within the lower Feather River. Exceedances occurred for three constituents: total aluminum, iron, and copper. All of the water quality sampling locations in the lower Feather River exceeded the NAWQC aquatic life standard for aluminum at least one time.

Fish habitat distribution was determined by dividing the lower Feather River into habitat units and assigning each habitat unit a proportion of relative habitat suitability class based on an analysis of each habitat component requirement for each species. Thus, fish habitat distribution was presented as the number of acres and the proportion of total habitat that fell within each proportion of relative habitat suitability class. The habitat distribution for 16 fish species was presented for each of 5 lower Feather River reaches as well as for the entire lower Feather River. The proportion of total available habitat that fell into the highest proportion of relative habitat suitability class (90 percent to 100 percent class) generally increased with distance downstream from the Fish Barrier Dam for American Shad, centrarchids, hitch, Sacramento splittail, Sacramento sucker, tule perch, and white sturgeon, and generally decreased with distance downstream from the Fish Barrier Dam for green sturgeon and striped bass. The proportion of total available habitat that fell into the highest proportion of relative habitat suitability class (90 percent to 100 percent) for hardhead and Sacramento pikeminnow displayed a relatively homogeneous distribution throughout the lower Feather River. A small proportion of total available habitat fell into the highest proportion of relative habitat suitability class (90 percent to 100 percent class) for Pacific lamprey and river lamprey in the most upstream reaches of the lower Feather River. Only the centrarchid fish species habitat distribution fell into one of the reduced proportion of relative habitat suitability classes in the upstream most reaches of the lower Feather River.

The amount of concurrence between habitat distribution and species distribution also was presented by species. In general, the reaches with the greatest area of the highest proportion of relative habitat suitability classes (75-89% and 90-100%) also had a high proportion of the “frequently observed” category of distribution for centrarchids.

Resource management decisions that affect the areas of the river in which there is disagreement between the species distribution and habitat distribution could require additional evaluation or be made with a higher degree of uncertainty of affects on the resources.

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1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION

Ongoing operation of the Oroville Facilities has the potential to influence fish species distribution and fish habitats. Operations of the Oroville Facilities affect the flow, stage, substrate, instream cover complexity, and water temperature in the Feather River downstream from the Thermalito Diversion Dam and these factors influence fish habitat relative suitability and consequently the relative abundance of several fish species. As a component of study plan (SP)-F3.2, *Evaluation of Project Effects on Non-salmonid Fish in the Feather River Downstream of the Thermalito Diversion Dam,* Task 4 of SP-F3.2, herein, identifies fish habitat in the Feather River from the Thermalito Diversion Dam to the Sacramento River confluence, as it pertains to species-specific habitat requirements, and Task 5 of SP-F3.2, herein, evaluates potential project effects on non-salmonid fish species, and integrates fish species distribution information and habitat requirements.

1.1.1 Statutory/Regulatory Requirements

Several fish species addressed in this analysis are special status species, meaning that they are federally or state-listed threatened or endangered species under the Endangered Species Act (ESA), species that are candidates for listing under the ESA, or species that are California species of special concern. Species in the lower Feather River with special regulatory status include Sacramento splittail (*Pogonichthys macrolepidotus*), green sturgeon (*Acipenser medirostris*), and river lamprey (*Lampetra ayresi*). The regulatory status of each of these species is described below.

On February 8, 1999, Sacramento splittail was designated as threatened under the ESA by the U.S. Fish and Wildlife Services (USFWS) (USFWS 1999). Splittail were listed as threatened throughout their entire range, which includes the Feather River (USFWS 1999). On September 22, 2003, USFWS issued a Notice of Remanded Determination for the Sacramento Splittail, which removed the Sacramento Splittail from the Endangered Species List (USFWS 2003). However, splittail still are considered a Species of Special Concern by the California Department of Fish and Game (DFG).

On June 12, 2001, the National Marine Fisheries Service (NOAA Fisheries) received a petition from the Environmental Protection Information Center, Center for Biological Diversity, and Waterkeepers Northern California regarding the North American green sturgeon, in which the petitioners requested that NOAA Fisheries list the species as either an endangered or threatened species under the ESA (Environmental Protection Information Center et al. 2001). On December 14, 2001, NOAA Fisheries announced a 90-day finding that the petition presents substantial scientific and commercial information indicating that listing the North American green sturgeon may be warranted (NOAA Fisheries 2001). While acceptance of the petition does not mean that listing is a given outcome, acceptance of the petition under the ESA requires that NOAA Fisheries promptly commence a status review for the species concerned and make a finding as to whether the petitioned action is warranted within 12 months of the receipt date of the petition. On January 23, 2003 NOAA Fisheries determined that green sturgeon listing was not warranted and that the status would be reevaluated after five years (NOAA Fisheries 2003).

In June of 1995, river lamprey was designated as a Species of Special Concern by DFG (Moyle et al. 1995). "Species of Special Concern" (SSC) status applies to animals not listed under the federal ESA or the California Endangered Species Act, but which nonetheless: 1) are declining at a rate that could result in listing; or 2) historically occurred in low numbers and known threats to their persistence currently exist (DFG 2002b). River lamprey are listed as a Class 3 Species of Special Concern, meaning that they occupy much of their native range, but were formerly more widespread or abundant within that range (Moyle et al. 1995).

In addition to the federal and state ESA, and California Fish and Game Code, Section 4.51(f)(3) of 18 CFR requires reporting of certain types of information in the Federal Energy Regulatory Commission (FERC) application for license of major hydropower projects, including a discussion of the fish, wildlife, and botanical resources in the vicinity of the project (FERC 2001). The discussion is required to identify the potential impacts of the project on these resources, including a description of any anticipated continuing impact for on-going and future operations.

In addition to species with special regulatory status, information regarding the distribution of fish of primary management concern (SP-F3.2) and predator and prey species of primary management concern (SP-F21) also was collected and compiled into fish distribution maps. As described in SP-F3.2, Task 1, non-salmonid fish of primary management concern include members of the *Centrarchidae* family (including black bass and sunfish), striped bass (*Morone saxatilis*), American shad (*Alosa sapidissima*), hardhead (*Mylopharodon conocephalus*), hitch (*Lavinia exilicauda*), Pacific lamprey (*Lampetra tridentat*a), Sacramento pikeminnow (*Ptychocheilus grandis*), Sacramento sucker (*Catostomus occidentalis*), tule perch (*Hysterocarpus traski*), and white sturgeon (*Acipenser transmontanus*) (DWR 2002c). As described in SP-F21, Task 2, prey species of primary management concern in the Feather River are juvenile anadromous salmonids, including juvenile Chinook salmon (*Oncorhynchus tshawytscha*) and juvenile steelhead (*Oncorhynchus mykiss*), and predator species of primary management concern include Sacramento pikeminnow and striped bass (DWR 2002c)

As a task of SP-F3.2, Task 4 fulfills a portion of the FERC application requirements by identifying fish habitat in the Feather River from the Thermalito Diversion Dam to the Sacramento River confluence, as it pertains to species-specific habitat requirements, and Task 5 evaluates potential project effects on non-salmonid fish species, and integrates fish species distribution information and habitat requirements. In addition to fulfilling these requirements, information collected during this task may be used in developing or evaluating potential Resource Actions.

1.1.2 Study Area

The study area for SP-F3.2, *Evaluation of Project Effects on Non-salmonid Fish in the Feather River Downstream of the Thermalito Diversion Dam,* encompasses the Feather River downstream from the Thermalito Diversion Dam to its confluence with the Sacramento River. The Thermalito Diversion Dam was named as the upstream extent of all tasks in SP-F3.2 because of the potential for Resource Actions to suggest allowing in-river fish passage of primarily salmonids into the Fish Barrier Pool. The area extending from the Thermalito Diversion Dam to the Fish Barrier Dam is a small reservoir called the Fish Barrier Pool. This reach was included as part of the study area for the tasks related to SP-F3.2 primarily to allow collection and analysis of data to evaluate potential passing salmonids into the Fish Barrier Pool. The Feather River confluence with the Sacramento River is the downstream boundary of this study plan because of the potential influence of flow releases on species and habitat distribution.

1.1.2.1 Description

Physical habitat: Flow regime

The reach of the Feather River extending from the Fish Barrier Dam to the Sacramento River is composed of two operationally distinct segments. The upstream segment extends from the Fish Barrier Dam at river mile (RM) 67.25 to the Thermalito Afterbay Outlet (RM 59), while the downstream segment extends from the Thermalito Afterbay Outlet (RM 59) to the confluence of the Feather and Sacramento Rivers (RM 0). The flow regime associated with each of these segments is distinct and is summarized below.

Minimum flows in the lower Feather River were established in an August 1983 agreement between DWR and DFG (DWR 1983). The agreement specified that DWR release 600 cubic feet per second (cfs) into the Feather River from the Thermalito Diversion Dam for fisheries purposes. Therefore, the reach of the Feather River extending from the Fish Barrier Dam to the Thermalito Afterbay Outlet is operated at 600 cfs all year, with variations in flow occurring rarely, only during flood control releases or in the summer in order to meet downstream water temperature requirements for salmonids.

Unlike the constant flow regime in the upstream segment of the Feather River, the flow regime in the reach of the Feather River extending from the Thermalito Afterbay Outlet (RM 59) to the confluence of the Feather and Sacramento rivers (RM 0) varies depending on runoff and month. For a Lake Oroville surface elevation greater than 733 feet, the minimum in-stream flow requirements on the Feather River below the Thermalito Afterbay Outlet are provided in Table 1.1-1 as follows:

Table 1.1-1 Minimum instream flow requirements in the lower Feather River.

Percent of normal[1] runoff (%)	Oct.-Feb. (cfs)	Mar. (cfs)	Apr.-Sep. (cfs)
> 55	1,700	1,700	1,000
< 55	1,200	1,000	1,000

[1] Normal runoff is defined as 1,942,000 acre-feet, which is the mean (1911 – 1960) April through July unimpaired runoff near Oroville.

Source: (DWR 1983)

Although the minimum flow requirements are described above, flow in the reach of the Feather River extending from the Thermalito Afterbay Outlet to the confluence of the Feather and Sacramento rivers typically varies from the minimum flow requirement to 7,500 cfs (DWR 1982b). Instream flow in the reach downstream from the Thermalito Afterbay Outlet is additionally influenced by small flow contributions from Honcut Creek and the Bear River, and by larger flow contributions from the Yuba River.

Physical habitat: geomorphology/topology/vegetation

The LFC of the Feather River, extending from the Fish Barrier Dam downstream to the Thermalito Afterbay Outlet is categorized by a sequence of shallow riffles, 2 meter to 5 meter deep pools and island bar complexes.

The river elevation drops a total of 37 feet in the 8.25 mile-long LFC, for a stream gradient of about 0.09 percent (DWR 1982a). Additionally, this section of the river channel is confined by levees that restrict overbank flooding and provide lateral channel control (DWR 2001). However, because of the confinement within levees, the LFC generally is less complex than the HFC, and has fewer meanders and less area in which channel migration could occur. Substrates in this segment are composed of relatively large elements with armoring occurring due to lack of recruitment of gravel from upstream and transport of gravels downstream out of the area (Sommer et al. 2001). Streambank vegetation in the area is seldom inundated due to the maintenance of constant flow regimes.

The second river segment is the HFC, which is the reach that extends from the Thermalito Afterbay Outlet (RM 59) downstream to the confluence with the Sacramento River at Verona (RM 0). Flow in the HFC also is governed by the 1983 agreement between DWR and DFG. In this reach, the river is not confined by levees over the entire reach and the channel bed and banks become more variable (DWR 1982b; DWR 2001). The river flows through undisturbed older alluvium and floodplain deposits, and active erosion contributes to siltation of gravels downstream (DWR 1982b; DWR 2001). Because the active channel in this reach is broader and wider than in the upper segment, more meanders and gravel bars occur in this reach. The width between confining levees in this reach varies dramatically. In some places, the width is about the same as the stream channel. In other places, several miles of floodplain exist between the levees. The substrate in the HFC tends to include relatively small gravel-sized particles transported from the upstream segment of the river (Sommer et al. 2001). Streamside vegetation in this area is more frequently inundated than riparian vegetation in the LFC, particularly in the spring, during high flow periods.

Chemical/Physical habitat: water temperature

Water temperature regimes in the LFC are driven by Feather River Fish Hatchery (FRFH) objectives described in the 1983 agreement between DWR and DFG (DWR 1983; DWR 2001). Hatchery water temperature objectives are depicted in Table 1.1-2. A water temperature range of plus or minus 4°F around the objectives from April through November is allowed. Meeting these water temperature objectives is facilitated by a shutter controlled intake gate system at the Oroville Dam that selects water for release from different reservoir depths (DWR 2001).

Table 1.1-2. Feather River Fish Hatchery water temperature objectives.

Period	Temperature (ºF)
April 1 - May 15	51º
May 16 – May 31	55º
June 1 - June 15	56º
June 16 – August 15	60º
August 16 – August 31	58º
September 1 – September 30	52º
October 1 – November 30	51º
December 1 – March 31	55º

Source. (DWR 1983; DWR 2001)

Water temperatures in the reach of the Feather River extending from the Thermalito Afterbay Outlet to the confluence with the Sacramento River typically are warmer than water temperatures in the upper reaches of the Feather River. Water temperatures in LFC are directly influenced by the temperature of releases from the Thermalito Afterbay Outlet. Because the Thermalito Afterbay is a large, shallow, warming basin, water that is released from the Thermalito Afterbay Outlet typically is warmer than the water originating from the LFC. Typically, the contribution to the total flow in the Feather River from the Thermalito Afterbay Outlet is generally greater than flow contribution from the LFC, and water temperatures in the river downstream from the Thermalito Afterbay Outlet generally are warmer than water temperatures in the reach upstream from the Thermalito Afterbay Outlet. For additional details regarding water temperature operational requirements, see section 1.3.1.2, Water Temperature Requirements.

Biological context

The lower Feather River supports a variety of fish species. The Feather River warmwater sport fishery is composed of fish in the sunfish family (Centrarchidae) including four species of black bass (*Micropterus punctulatus*, *M. salmoides*, *M. dolomieui*, and *M. coosae*), three species of sunfish (*Lepomis macrochirus*, *L.*

cyanellus, and *L. microlophus*), and two species of crappie (*Pomoxis nigromaculatus* and *P. annularis*) (DWR 2001). Additionally, striped bass (*Morone saxatilis*) and American shad (*Alosa sapidissima*) are also common targets for anglers. The Feather River also provides habitat for many other fish species, including native fishes (e.g., Sacramento pikeminnow (*Ptychocheilus grandis*), hardhead (*Mylopharodon conocephalus*), Sacramento sucker (*Catostomus occidentalis*), Sacramento splittail (*Pogonichthys macrolepidotus*), river lamprey (*Lampetra ayresi*), Pacific lamprey (*L. tridentata*), tule perch (*Hysterocarpus traski*), hitch (*Lavinia exilicauda*), green sturgeon (*Acipenser medirostris*), and white sturgeon (*A. transmontanus*)), and introduced fishes including common carp (*Cyprinus carpio*), wakasagi (*Hypomesus nipponensis*), and threadfin shad (*Dorosoma petenense*).

Sacramento pikeminnow (*Ptychocheilus grandis*)

The water temperatures preferred by Sacramento pikeminnow during spawning were reported to be above 14.0°C (57.2°F) in the Sacramento – San Joaquin River System tributaries (Wang and Brown 1993). Sacramento pikeminnow also have been reported to reproduce in the largest, warmest tributaries with in the Eel River drainage (Harvey et al. 2002). Within the Sacramento – San Joaquin River system, Sacramento pikeminnow eggs have been reported to hatch in four to seven days at a water temperature of 18.0°C (64.4°F) (Moyle 2002). The reported preferred range for rearing juvenile pikeminnow was 17.7°C (63.9°F) to 24.5°C (76.1°F) in the Eel River tributaries (Harvey et al. 2002). For adults, the preferred maximum water temperature within the Sacramento – San Joaquin River systems was around 26.0°C (78.8°F), while water temperatures above 38.0°C (100.4°F) were reported to be lethal (Moyle 2002). Additionally, Sacramento pikeminnow were reported to show an increased sensitivity to low dissolved oxygen after an abrupt 5.0°C (41.0°F) temperature increase at water temperatures between 10.0°C (50.0°F) and 25.0°C (77.0°F) (Cech Jr. et al. 1990).

The preferred spawning habitat of Sacramento pikeminnow within the Sacramento River system reportedly was composed of gravel riffles or shallow flowing areas at the base of the pools (Moyle 2002). Preferred spawning depth of a related species, the northern pikeminnow, was reported to be from 5 cm to 20 cm, as observed within the Merwin Reservoir, Washington (Patten and Rodman 1969). Additionally, it has been reported by Gadomski (2001) that various studies have shown that cyprinid larvae prefer shallow, low velocity vegetated habitats (Gadomski et al. 2001). Juvenile pikeminnow were reported to be observed most often using pools within the Van Duzen River, California (Brown and Moyle 1997). The depth range within the Eel River reported to be utilized by adult pikeminnow was 44 cm to 115 cm (Brown and Moyle 1991). Later studies by the same investigators reported that the depth preference within the Eel River was 45 cm (Brown and Moyle 1997) and within the Eel River tributaries was 28 cm (Harvey and Nakamoto 1999).

<u>Hardhead</u> (*Mylopharodon conocephalus*)

The reported preferred temperature range for spawning hardhead is 15.0°C to 18.0°C (59.0°F-64.4°F) (Wang 1986). Little literature exists to support identification of index water temperatures for incubation, early development and juvenile rearing. Adults, however, are found in streams that have average summer water temperatures greater than 20.0°C (68.0°F) (Moyle et al. 1995). Moyle reported that the preferred water temperature, in laboratory conditions was between 24.0°C and 28.0°C (75.2°F-82.4°F) (Moyle 2002). Like many species, at high water temperatures hardhead are reported to be relatively intolerant of low oxygen levels (Moyle 2002).

Hardhead spawning nests reportedly were constructed in gravel in riffles, runs, or at the heads of pools (Moyle 2002). After hatching, the larval and post larval fish were reported to remain along stream edges in dense cover of flooded vegetation or fallen tree branches. As juvenile hardhead grow they move to deeper habitats. Small juveniles may concentrate along the edges of rivers and ponds among large cobbles and boulders. At two cm to five cm in length, juveniles begin to select habitats similar those of adults (Moyle 2002). Adults were reported to be found in the deep, slow moving pools of rivers and streams (Page and Burr 1991). Additionally, adults often remain in the lower half of the water column, although in reservoirs they can be occasionally be seen hovering close to the surface (Moyle 2002). Hardhead substrate preference was reported to be sand, gravel, and boulders (Cooper 1983).

<u>Sacramento splittail</u> (*Pogonichthys macrolepidotus*)

The onset of spawning has been reported to be associated with increasing water temperatures between 14.0°C and 19.0°C (57.2°F-66.2°F) (Moyle 2002). Other studies report that the water temperature preference for spawning splittail was between 9.0°C and 20.0°C (48.2°F-68.0°F) (Caywood 1974). In a laboratory study, Young et al. (1996), showed that juvenile splittail tolerated minimum water temperatures between 6.5°C and 7.3°C (44.1°F-45.1°F) and maximum water temperatures between 20.5°C and 33.0°C (68.9°F-91.4°F) depending on acclimation water temperature and age (the study tested age zero through age two individuals). Moyle (2002) reported that adult splittail are found at water temperatures between 5.0°C and 24.0°C (41.0°F and 75.2°F) (Moyle 2002). However, fish acclimated to high water temperatures can survive rapid water temperature changes and maximum water temperatures between 29.0°C and 33.0°C (84.2°F-91.4°F) for short periods (Moyle 2002). All sizes of Sacramento splittail can survive less than 1 mg/L dissolved oxygen concentration (Moyle 2002).

Wang (1986) reported that spawning occurs in flooded riverbeds and submerged vegetation in flooded areas (U. S. Fish and Wildlife Service Endangered Species Program Website 2003). After hatching, larvae remain in shallow, weedy areas until water recedes, and then they migrate downstream (Meng and Moyle 1995). Juvenile rearing occurs in shallow-water habitat with emergent vegetation (i.e., tules and reeds)

(Meng and Moyle 1995). The reported depth preference for adult splittail was less than or equal to 22 ft (less than or equal to 6.7 m). In addition, preferred habitat was reported to include shallow sloughs lined with tules and reeds, which provide rich feeding grounds and refuge from predators (Meng and Moyle 1995).

<u>Sacramento sucker</u> (*Catostomus occidentalis*)

The water temperature range at which Sacramento sucker spawning has been reported to occur is between 12.0°C and 18.0°C (53.6°F–64.4°F) (Moyle 2002). Although little information regarding incubation, early development, juvenile rearing, and adult water temperature preferences are unknown, Moyle (2002) reported that Sacramento sucker, "are not particularly fussy when it comes to choosing water temperatures (Moyle 2002)." Sacramento sucker were reported to be found in streams where water temperatures rarely exceed 15.0°C to 16.0°C (59.0°F-60.8°F) and in streams where water temperatures may reach 29.0°C to 30.0°C (82.4°F-86.0°F) (Moyle 2002). Moyle (2002) also suggested that Sacramento sucker preferred water temperatures between 20.0°C and 25.0°C (68.0°F-77.0°F), which may be optimal for growth (Moyle 2002). Little information is available on suitable, preferred, or optimal dissolved oxygen concentrations for Sacramento sucker.

The preferred spawning substrate of Sacramento sucker was reported to be sand, gravel, and cobble (Wang 1986). Newly hatched larvae usually remain within the interstices of the spawning gravel until the yolk sac is absorbed (Wang 1986). Juvenile rearing reportedly occurs in shallow areas and larval suckers less than 14 mm SL concentrate over detritus or among emergent vegetation in warm, protected stream margins (Moyle 2002). Sacramento suckers have been found in a wide variety of water from cold, rapidly flowing streams to warm sloughs of low salinity sections of the San Francisco Estuary. Sacramento suckers were reportedly most abundant in clear, cool streams and rivers and in lakes and reservoirs at moderate elevations, however (Moyle 2002).

<u>River Lamprey</u> (*Lampetra ayresi*)

The water temperature range at which river lamprey have been reported to spawn is between 13.0°C and 13.5°C (55.4°F-56.3°F) (Wang 1986). There is little information on water temperature preferences and dissolved oxygen concentration tolerances for incubation, early development, juvenile, and adult river lamprey and there are few records on river lamprey in California (Moyle 2002).

Spawning substrate was reported to range from rocks to gravel (Wang 1986), but preferred spawning habitat was reported to be gravel in riffles (Moyle 2002). Early developing river lamprey in the form of ammocoetes burrow into sandy or muddy substrates near the banks of rivers (Wang 1986). Juvenile cover preference is reported to be silty backwaters and eddies (Moyle 2002).

<u>Pacific lamprey</u> (*Lampetra tridentata*)

The water temperature range at which Pacific lamprey have been reported to spawn was between 12°C and 18°C (53.6°F-64.4°F) (Moyle 2002). Water temperatures tolerated for incubation ranged from 10.0°C to 18.0°C (50°F-64.4°F) in laboratory conditions. At 22.0°C (71.6°F) survival is reported to drop significantly for both incubation and juvenile rearing (Meeuwig et al. 2002). The reported preferred water temperature for incubation and early development was 15.0°C (59.0°F) (Moyle 2002). Little information was available regarding adult water temperature preferences and tolerances.

The substrate preferred for spawning was reported to be gravel (Moyle 2002). Generally spawning occurs on sand and gravel in moderate to swift currents (lotic environment), but adult Pacific lamprey also were observed to spawn in stagnant and muddy environments (lentic environment) (Whyte et al. 1993). Hatching ammocoetes are reported to spend a short time in nest gravel, eventually swimming up into the current where they are washed downstream to areas of soft sand and mud (Moyle 2002). Larvae burrow into soft sediments in shallow areas along the stream banks (Close 2001). Metamorphosing lamprey move from muddy habitat in lentic waters to habitats with silt covered large gravel (1 cm to 4 cm in diameter) and moderate currents (Beamish 1980). The preferred median depth for holding adults was reported to be 0.9 m (3 ft) (Bayer et al. 2001). Immature Pacific lamprey were reported to hide in stones and logs for several months to a year until fully mature (Moyle 2002).

<u>Tule perch</u> (*Hysterocarpus traski*)

Tule perch bear live young and are reported to give birth when water temperatures are between 18.0°C and 20.0°C (64.4-68.0°F) (Wang 1986). Little is known about water temperature preference for early development and juvenile rearing, however. Adult water temperature preference is reported to be lower than 22.0°C (71.6°F) (Moyle 2002) and adults are not generally found in areas with water temperatures greater than 25.0°C (77.0°F) (Moyle 2002). Tule perch generally require cool, well-oxygenated water (Moyle 2002).

Tule perch were reported to spawn among tule marshes and other types of emergent vegetation (Wang 1986). Adults were reported to prefer mud to gravel bottomed pools and runs. Additionally, tule perch are found in low elevation rivers and lakes, usually near emergent plants or overhanging banks . In addition, Moyle (2002) found tule perch in areas with beds of emergent aquatic plants, deep pools, and banks with complex cover, such as overhanging bushes, fallen trees, undercutting, and riprap (Moyle 2002). Pregnant females reportedly were concealed in slower moving areas or backwaters with beds of aquatic plants or with dense cover created by tree branches (Moyle 2002).

<u>Green sturgeon</u> (*Acipenser medirostris*)

The water temperature at which green sturgeon are reported to spawn is between 8.0°C and 14.0°C (46.4°F-57.2°F) (Moyle 2002; DFG website 2002). The California Department of Fish and Game, however, reported the water temperature range for spawning to be between 10.0°C and 21.1°C (50.0°F-70.0°F) (DFG 2001a). The preferred water temperature for spawning was reportedly between 8.0°C and 14.0°C (46.4°F-57.2°F), which is somewhat colder than the preferred water temperature reported for white sturgeon (USFWS 1995b). Water temperatures greater than 20.0°C (68°F) were reported to be lethal to embryos (Beamesderfer and Webb 2002a). Adults in the Klamath River were reported to be found in water between 6.9°C and 16.0°C (44.4°F-60.8°F) (USFWS 1995b). Little information exists regarding dissolved oxygen concentration requirements of green sturgeon.

The preferred spawning substrate was reported to be large cobble, with crevices in which eggs become trapped and develop and generally areas with rocky bottoms (Beamesderfer and Webb 2002b). Preferred spawning depth was reported to be greater than nine feet (>2.7 m) in relatively high velocity pool habitats (USFWS 1995b). Larvae were reported to stay close to the bottom and rear in rivers upstream of estuaries. Green sturgeon larvae reportedly do not move up the water column to avoid being transported downstream (DFG 2001b).

<u>White sturgeon</u> (*Acipenser transmontanus*)

The water temperature range in which white sturgeon spawning reportedly occurs varies between studies. The ranges reported are 10.0°C to 18.0°C (50.0°F-64.4°F) (Parsley et al. 1993) and 7.8°C–to 17.8°C (46.0-64.0°F) (Kohlhorst 1976). The preferred water temperatures for white sturgeon spawning were reported to be 14.0°C (57.2°F) and 14.4°C (57.9°F) by Parsley (1993) and Kohlhorst (1976), respectively. Additionally the optimal water temperature for spawning was reported by Gadomski et al. (2002) to be 13.3°C (55.9°F) (Gadomski et al. 2002). Elevated mortality occurred among developing white sturgeon embryo’s incubated at 18.0°C (64.4°F), and complete mortality occurred when embryos were incubated at 20.0°C (68.0°F) (Parsley et al. 1993). The median water temperature at which spawning was reported to occur was 14.0°C (57.2°F) and is equivalent to the water temperature identified as most suitable for white sturgeon egg development (Parsley et al. 1993). The preferred water temperature for rearing juveniles was reported to be 18.0°C (64.4°F) (Moyle 2002). The water temperature range in which adult white sturgeon have been observed has been reported to be between 0°C and 24.0°C (32°F-75.2°F) (Fishbase Website 2003). Little is known about the dissolved oxygen concentration requirements of white sturgeon.

The range of substrate over which adult white sturgeon have been reported to spawn is characterized by cobble and bolder substrates, but some sturgeon reportedly also were found over sand, gravel and bedrock (Parsley et al. 1993). White sturgeon spawning was also reported to take place over deep gravel riffles or in deep holes with swift currents over rock bottoms (Moyle 2002). The depth range preferred for spawning was reported to be between four meters and 24 meters deep (Parsley et al. 1993). Newly hatched larvae have been observed swimming towards the surface and remaining in the water column for a length of time that was inversely related to water velocity. The larvae were then observed seeking cover in or on the substrate and were reported to appear to be photophobic (Parsley et al. 1993). Parsley (1993) also reported that the hiding phase lasted until the yolk was absorbed (approximately 12 days after hatch) (Parsley et al. 1993). Additionally, juvenile white sturgeon were reported to prefer cover within the thalweg (Parsley et al. 1993). Adults have been observed at depths between two meters and 30 meters (Counihan et al. 1998). White sturgeon adults are reported to reside in shallower water during periods of high activity (summer) and deeper water in the winter (Brannon and Sutter 1992). Sites where white sturgeon showed the highest residence times had substrates consisting of mostly very fine sediment (Brannon and Sutter 1992).

Centrarchidae (black bass and sunfish family)

Spotted bass (***Micropterus punctulatus***)

Water temperatures at which spotted bass have been reported to spawn range between 15°C and 23°C (59.0°F and 64.4°F) (Moyle 2002). Additionally, Moyle (2002) reported spotted bass spawning in California at 14°C (57.2°F). Spotted bass were reported hatching at water temperatures of 16.5°C to 20.0°C (61.7°F-68.0°F) (Sammons et al. 1999). Little is known about juvenile spotted bass water temperature preferences. Adults have been observed in areas where water temperatures range from 24.0°C to 31.0°C (75.2°F-87.8°F) during the summer (Moyle 2002). Coutant (1977) reported that Cherry and others (1975) determined the water temperature preferences of adult spotted bass in the laboratory. The results of the study indicated that adult spotted bass preferentially chose a water temperature of 32.5°C (90.5°F) (Coutant 1977). Little is known about the dissolved oxygen tolerances of spotted bass.

Spawning substrate for spotted bass has been characterized as including large rocks, rubble, and gravel (Moyle 2002), and the reported preferred substrate was characterized as large rocks with limited areas of rubble (Aasen and Henry 1981). Nest depth was reported to be between 0.5 m and 4.6 m (1.6 ft and 15.1 ft), with the average nest depth between 2.5 m and 3.0 m (8.2 ft and 9.8 ft) (Moyle 2002). Moyle (2002) reported that juveniles remain near shore in shallow water and young-of-year bass often were found in small shoals. Moyle (2002) also reported that in streams, spotted bass adults are secretive pool dwellers, avoiding riffles and backwaters with heavy growths of aquatic plants, they prefer slower, more turbid waters than smallmouth bass and faster water than largemouth bass (Moyle 2002). Spotted bass tend to congregate in water from one meter to four meters deep and, in reservoirs, can often be found just above the thermocline. They also tend to seek out deep water (30m to 40m) in reservoirs when water temperatures become uniform (Moyle 2002).

<u>Largemouth bass</u> (*Micropterus salmoides*)

Largemouth bass nest building was reported to begin at 15.0°C to 16.0°C (59.0°F-60.8°F), and spawning continues up to 24.0°C (75.2°F) (Moyle 2002). Nesting success was reportedly reduced if water temperatures were reduced below 15.5°C (59.9°F) (Davis and Lock 1997). At 20.0°C (68.0°F) and 23.0°C (73.4°F), dissolved oxygen concentrations as low as 35 percent saturation are reported to be adequate for embryo and larvae survival (Carlson 1973). Juvenile rearing and growth reportedly occurs at water temperatures between 10.0°C and 35.0°C (50.0°F-95.0°F) (Moyle 2002). Juvenile largemouth bass, however, have been reported to prefer water temperatures of 30°C to 32°C (86°F-89.6°F) (Moyle 2002). Given a choice, adult largemouth bass preferred a water temperature of 27.0°C (80.6°F), they can persist in water where temperatures reach 36.0°C to 37.0°C (96.8-98.6°F) during the day with dissolved oxygen concentrations as low as 1 mg/L (Moyle 2002).

Spawning has been reported to occur mostly over gravel, mud and sand substrates, and muddy areas below boulders (Wang 1986). In addition, spawning has been reported to occur next to submerged objects, such as logs or boulders (Moyle 2002). Moyle (2002) reported that the range for spawning depth was 0.5 m to two meters (1.6 ft to 6.6 ft), in California. However, in reservoirs with frequent or large fluctuations in water level, spawning can occur as deep as four to five meters (13.1 ft to 16.4 ft) (Moyle 2002). Juveniles stay close to shore in schools that cruise near or above beds of aquatic plants (Moyle 2002). The overall habitat preference for adults was reported to be warm, shallow water of moderate clarity with beds of aquatic plants. Specifically, largemouth bass can be found in farm ponds, lakes, reservoirs, sloughs, and river backwaters where other nonnative fish are abundant, and heavy growth of aquatic plants are present (Moyle 2002). The preferred depth for adults was reported to be less than 6 m (19.7 ft) and could be as shallow as one to three meters (3.2 ft to 9.9 ft) (Moyle 2002).

<u>Smallmouth bass</u> (*Micropterus dolomieu*)

The water temperature range at which spawning was reported to occur ranged from 12.5°C to 23.5°C (54.5°F-74.3°F) (Graham and Orth 1986). Eggs are reported to hatch in 10 days at 12.8°C (55.0°F), and as rapidly as 2.5 days at 25.6°C (78.1°F) (Wang 1986). The reported water temperature preference for rearing juvenile smallmouth bass was 18.0°C (64.4°F) for young-of-year in winter, 19.0°C to 24.0°C (66.2°F-75.2°F) for young-of-year in spring, 31.0°C (87.8°F) for young-of-year in summer, and 24.0°C to 27.0°C (75.2°F-80.6°F) in fall. Adult smallmouth bass reportedly preferred water between 25.0°C and 27.0°C (77.0°F-80.6°F) (Moyle 2002). Dissolved oxygen concentrations in excess of 6.0 mg/L are needed for growth, while dissolved oxygen concentrations between 1 mg/L and 3 mg/L are adequate for survival (Moyle 2002).

The reported preferred spawning substrate of smallmouth bass consists of rubble, gravel, sand near submerged logs, boulders, or other cover (Moyle 2002). Spawning was reported to take place in shallow water, between 0.5 m and five meters deep (1.6 ft to 16.4 ft) (Moyle 2002). Newly hatched larva remain on the bottom of the nest for three to four days (Moyle 2002). Juvenile habitat preference was reported to be sandy shoals, rocky areas, and shallow stream pools with sand and rocky bottoms (Wang 1986). The depth at which adult smallmouth bass were observed ranged from one to ten meters (3.3 ft to 32.8 ft) (Moyle 2002). Additionally, smallmouth bass are reported to concentrate in narrow bays or in areas along the shore where rocky shelves project under water (Moyle 2002).

Redeye bass (*Micropterus coosae*)

Redeye bass have been reported to spawn in water with temperatures ranging from 17.0°C to 21.0°C (62.6°F-69.8°F) (Moyle 2002). The water temperature range in which redeye bass were found in California during summer was reported to be 26.0°C to 28.0°C (78.8°F-82.4°F) (Moyle 2002). Little information exists regarding dissolved oxygen concentration tolerances of redeye bass.

The spawning nest construction and parental behavior of redeye bass was reported to be similar to smallmouth bass with males constructing nests in beds of gravel (Moyle 2002). Adults are reported to favor pools, and pockets of water near boulders and undercut banks (Moyle 2002). Little is known about depth preferences of redeye bass.

Bluegill (*Lepomis macrochirus*)

The water temperature range at which spawning Bluegill have been observed was reported to be 18.0°C to 21.0°C (64.4°F-69.8°F) (Moyle 2002). Eggs are reported to hatch in two to three days at 20.0°C (68.0°F) (Moyle 2002). The water temperatures reported by Neill (1971) in Coutant (1977) to be preferred by rearing bluegill in lab studies were 30.2°C (86.4°F) during the day and 31.5°C (88.7°F) during the night (Coutant 1977). Maximum growth and reproduction was reported to occur at dissolved oxygen concentrations between four mg/L and eight mg/L, although bluegill can survive dissolved oxygen concentrations that are less than one mg/L (Moyle 2002). Adults are reported to survive winter water temperatures as low as 2.0°C (35.6°F), and summer water temperatures as high as 41.0°C (105.8°F) (Moyle 2002).

Spawning nests were reported to have been constructed on the bottoms of gravel, sand or mud that contain pieces of debris (Moyle 2002). In addition, Wang (1986) reported that nests were interspersed with debris in the form of twigs or dead leaves, sand or hard clay, and eggs were deposited on sticks or dead leaves (Wang 1986). Newly hatched larvae remain in the nesting area, while free-swimming larvae inhabit shallow water with vegetation (Wang 1986). Adult males reportedly guard embryos and fry during incubation and for about one week after hatching (Moyle 2002). Rearing juveniles swim in small schools near or among plant beds (Wang 1986). Adults reportedly prefer rooted aquatic plants as cover in areas with substrates of silt, sand, or gravel and have a preference for areas shallower than five meters (16.4 ft) (Moyle 2002).

<u>Green sunfish</u> (*Lepomis cynellus*)

The reported water temperature range in which green sunfish spawn was 15.0°C to 28.0°C (59.0°F-82.4°F) (Moyle 2002). In California, however, Moyle (2002) reported that spawning does not begin until water temperatures reach 19.0°C (66.2°F) (Moyle 2002). Lab studies indicated that green sunfish eggs hatched in 55 hours at 24°C (75.2°F) and took 35 hours to hatch at 27°C (80.6°F) (Taubert 1977). Juveniles given a choice in laboratory studies performed by Beittinger et al. (1975) were reported by Coutant (1977) to prefer a water temperature of 28.2°C (82.8°F) (Coutant 1977). Adults reportedly can survive water temperatures greater than 38.0°C (100.4°F) (Moyle 2002). In lab studies conducted by Cherry et al. (1975) and later summarized by Coutant (1977), adults reportedly preferred a water temperature of 30.6°C (87.1°F) (Coutant 1977). Green sunfish were reported to be able to withstand dissolved oxygen concentrations less than one mg/L (Moyle 2002).

Spawning substrate was characterized as consisting of gravel, clumps of vegetation or rock among the branches of fallen trees (Wang 1986) and fine gravel near overhanging bushes or other cover (Moyle 2002). Nests were reportedly constructed four to 50 cm (1.6 in to 19.7 in) from the surface (Moyle 2002). The habitat preferred by rearing juveniles was reported as mostly shallow, still or low velocity waters and small ponds with dense vegetation, ditches with filamentous algae, or inshore areas of large reservoirs (Wang 1986). The reported habitat preference for adults was characterized as being shallow with weedy areas, or generally areas with aquatic plant growth with muddy bottoms. In addition, small, warm streams, or intermittent ponds and lake edges that contain more than three to four other species were reported to be utilized by adult green sunfish (Moyle 2002).

<u>Redear sunfish</u> (*Lepomis microlophus*)

The water temperature range in which redear sunfish spawning is reported to occur is between 21.0°C and 24.0°C (69.8-75.2°F). The depth at which spawning is reported to occur ranges from 0.5 m to six meters deep (1.6 ft to 19.7 ft) (Moyle 2002). Incubation and early development was reported to occur in water where temperatures reached up to 23.6°C (74.5°F). Little information exists on water temperature and dissolved oxygen concentration requirements and tolerance ranges for other redear sunfish life stages.

The preferred spawning substrate of redear sunfish is reported to be gravel, sand, and hard clay in shallow waters of ponds and reservoirs (Wang 1986). Larvae are planktonic at first, before settling into beds of aquatic plants (Moyle 2002). Juveniles were reported to stay close to or in aquatic plant beds, often in small shoals (Moyle 2002). Adult habitat is reported to be characterized by deeper waters of warm, quiet ponds, lakes and river backwaters, and sloughs with substantial beds of aquatic vegetation (Moyle 2002).

<u>Black Crappie</u> (*Pomoxis nigromaculatus*)

The water temperature range at which spawning occurs was reported as exceeding 14.0°C to 17.0°C (57.2°F-62.6°F) and the preferred water temperature range was reported to be between 18.0°C and 20.0°C (64.4°F-68.0°F) (Moyle 2002). Incubation was reported to take two to three days at 18.3°C (64.9°F) (Wang 1986). In lab studies Coutant (1977) reported studies conducted by Neill (1971), which suggested that small individual juveniles were reported to tolerate water temperature ranges of 26.5°C to 30.0°C (79.7°F-86.0°F) during the day and 25.5°C to 29.5°C (77.9°F-85.1°F) at night (Coutant 1977). Other studies performed by Reutter and Herdendorf (1974) and reviewed by Coutant (1977), however, reported that the preferred water temperatures for adults were: 20.5°C (68.9°F) during winter, 21.0°C (69.8°F) during spring, 21.7°C (71.1°F) during summer, and 22.2°C (72.0°F) during fall (Coutant 1977). Little information exists describing the dissolved oxygen concentration tolerances of black crappie.

Spawning substrate was characterized as mud, gravel, or beds of aquatic plants, which were reported to occur in water less than one meter deep (Moyle 2002). Juveniles reportedly prefer quiet shallow water with patchy vegetation (Wang 1986). Little is known about the cover preferences of black crappie.

<u>White Crappie</u> (Pomoxis annularis)

The water temperature range at which white crappie reportedly spawn is between 17.0°C and 20.0°C (62.6°F-68.0°F) (Moyle 2002). Water temperatures reportedly tolerated during incubation ranged from 14.4°C to 22.8°C (57.9°F-73.0°F), while the preferred water temperature range was reported to range between 18.9°C and 19.4°C (66.0°F-66.9°F) (Siefert 1968). In laboratory studies, performed by Reutter and Herdendorf (1974) and reviewed and reported by Coutant (1977) water temperature preferences for adults were, 19.8°C (67.6°F) during winter, 18.3°C (64.9°F) during spring, and 10.4°C (50.7°F) during fall (Coutant 1977). Little information exists regarding dissolved oxygen concentration preferences of white crappie.

Nests for spawning are usually constructed by males in colonies underneath or close to overhanging bushes or banks in water less than one meter deep (3.3 ft). Occasionally nests are built in water as deep as six to seven meters (19.7 ft to 23 ft). Nests usually consist of shallow depressions in hard clay (rarely in sand or gravel) near or in beds of aquatic plants, algae, or submerged plant debris (Moyle 2002). Adults were reported to be littoral, living near the shore and were most abundant in warm turbid lakes, reservoirs, and river backwaters (Moyle 2002). Little is known about the depth preferences of white crappie.

<u>Striped bass</u> (*Morone saxatilis*)

No spawning was reported to occur when water temperatures were below 14.0°C (57.2°F) or above 21.0°C (69.8°F) within the Sacramento-San Joaquin River system (Moyle 2002). However, in some parts of California, striped bass were observed spawning when water temperatures were between 12.0°C and 22.0°C (53.6°F-71.6°F) (SWRI 2002). Most striped bass spawning reportedly occurred in the Sacramento-San Joaquin River system, within the water temperature range of 15.0°C to 20.0°C (59°F-68°F) (Moyle 2002). The reported water temperature range for striped bass incubation was 16.0°C to 19.0°C (60.8°F-66.2°F), as observed within a variety of estuaries along the west coast (Emmett et al. 1991). In laboratory experiments performed by Meldrim and Gift (1971) and reviewed by Coutant (1977), the reported upper avoidance water temperature of small juvenile striped bass was 34.4°C (93.9°F) (Meldrim and Gift 1971) (Coutant 1977). Water temperatures between 12.8°C and 23.9°C (55.0°F-75.0°F) were reported to be suitable for developing larvae and juveniles (SWRI 2002). Adults and juveniles within the Sacramento-San Joaquin River system were reported to be able to survive water temperatures as high as 34.0°C (93.2°F) for short periods of time (Moyle 2002). Stress levels are reported to begin rising at water temperatures greater than 25.0°C (77.0°F) and water temperatures reportedly reach lethal levels beginning at water temperatures greater than 30.0°C (86.0°F) (Moyle 2002). Striped bass can reportedly withstand three mg/L to five mg/L dissolved oxygen concentrations for short periods, based on observations within the Sacramento-San Joaquin River system. (Moyle 2002). Five mg/L was the recommended dissolved oxygen concentration for adequately maintaining a population of striped bass (SWRI 2002).

The preferred spawning substrate of striped bass, based on observations in the Annapolis River Nova Scotia, Canada, was reportedly mainly sand interspersed between basalt and granite boulders (Rulifson and Dadswell 1995). The reported average depth of spawning striped bass in the San Joaquin River was between 3.05 m and 22.9 m (10 ft and 75 ft) (Stevens 1966). Juveniles reportedly prefer clean, sandy substrates, but they have been found over gravel beaches, rock, mud, and mixed sand/silt substrates within estuaries along the west coast (Emmett et al. 1991). As observed within the Sacramento-San Joaquin River system, the average depth at which adults were observed was between 9.1m and 12.2m (30 ft and 40 ft) deep (Stevens 1966). Based on observations within the Saint Lawrence River and estuary, striped bass frequent shoreline coves and small streams (Rulifson and Dadswell 1995).

<u>American shad</u> (*Alosa sapidissima*)

The preferred water temperature in the Sacramento River for spawning American shad reportedly ranged from 17.0°C to 24.0°C (62.6°F-75.2°F) (Moyle 2002). In the Feather River, the suitable water temperatures for spawning and egg survival were reportedly between 15.6°C and 21.1°C (60.1°F-70.0°F) (Painter et al. 1979). Moyle (2002) reported that the minimum dissolved oxygen concentration required for spawning American shad was five mg/L (Moyle 2002). The reported preferred water temperatures for rearing juveniles in the Sacramento River were 17.0°C to 25.0°C (62.6°F-77.0°F) (Moyle 2002). Little is known about adult water temperature preferences, although upstream migration may discontinue if water temperatures exceed 20.0°C (68.0°F) (Stier and Crance 1985).

Nest construction was reported to usually occur in sand and gravel in main channels of rivers (Moyle 2002). American shad spawning generally was reported to occur on broad flats in shallow waters (Painter et al. 1979). Preferred spawning depths are reported to be shallower than three meters (9.8 ft) (Moyle 2002). In a study conducted on the upper Delaware River, no relationship between juvenile abundance and habitat type was found, suggesting general use of most riverine habitat types. A positive relationship was found between juvenile abundance and cool water temperatures in riffles and also between and juvenile abundance and submerged aquatic vegetation (Ross et al. 1997). Little evidence was found indicating a depth preference for adult American shad.

1.2 DESCRIPTION OF FACILITIES

The Oroville Facilities were developed as part of the State Water Project (SWP), a water storage and delivery system of reservoirs, aqueducts, power plants, and pumping plants. The main purpose of the SWP is to store and distribute water to supplement the needs of urban and agricultural water users in northern California, the San Francisco Bay area, the San Joaquin Valley, and southern California. The Oroville Facilities are also operated for flood management, power generation, to improve water quality in the Delta, provide recreation, and enhance fish and wildlife.

FERC Project No. 2100 encompasses 41,100 acres and includes Oroville Dam and Reservoir, three power plants (Hyatt Pumping-Generating Plant, Thermalito Diversion Dam Power Plant, and Thermalito Pumping-Generating Plant), Thermalito Diversion Dam, the Feather River Fish Hatchery and Fish Barrier Dam, Thermalito Power Canal, Oroville Wildlife Area (OWA), Thermalito Forebay and Forebay Dam, Thermalito Afterbay and Afterbay Dam, and transmission lines, as well as a number of recreational facilities. An overview of these facilities is provided on Figure 1.2-1. The Oroville Dam, along with two small saddle dams, impounds Lake Oroville, a 3.5-million-acre-feet (maf) capacity storage reservoir with a surface area of 15,810 acres at its normal maximum operating level.

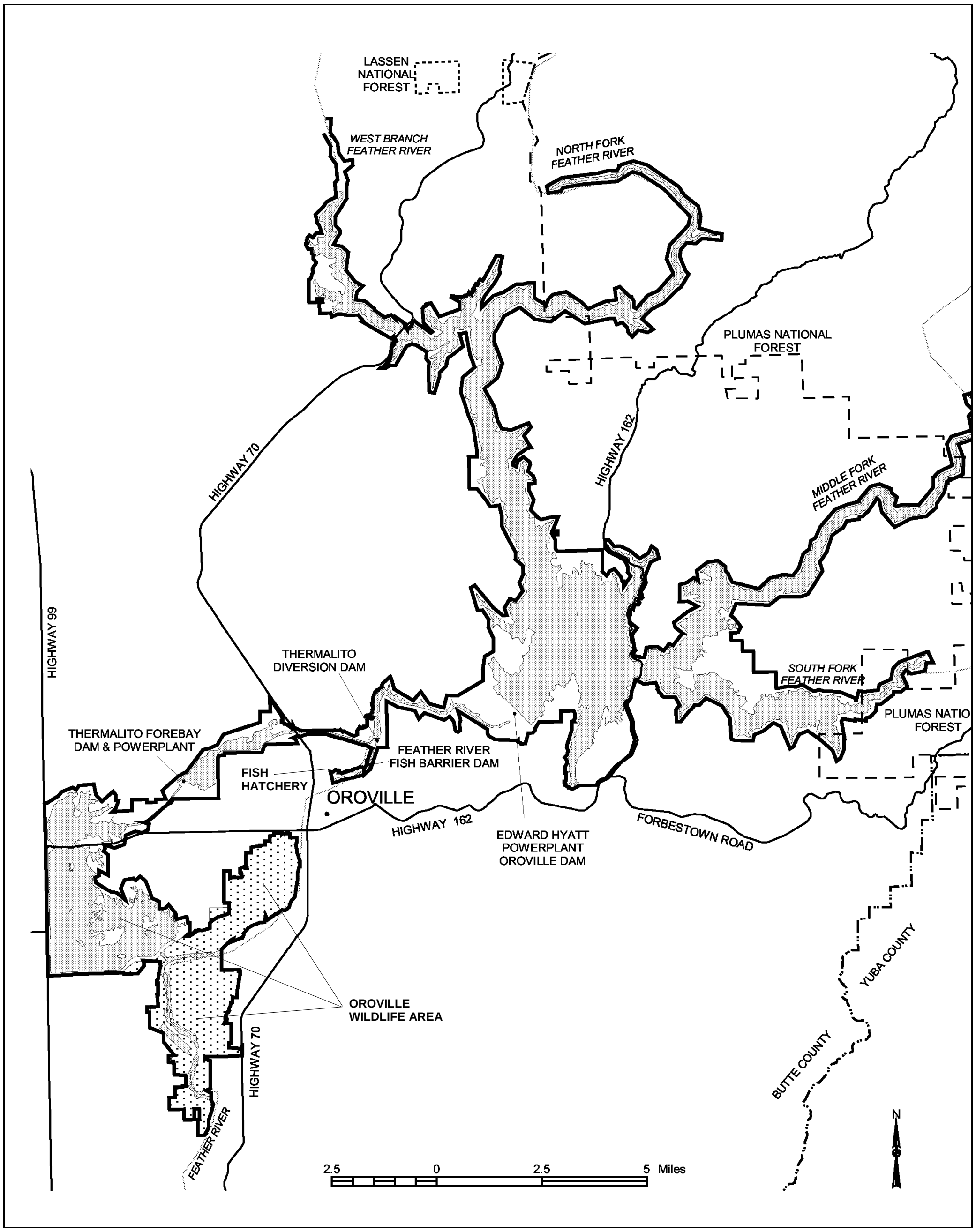


Figure 1.2-1. Oroville Facilities FERC Project Boundary.

The hydroelectric facilities have a combined licensed generating capacity of approximately 762 megawatts (MW). The Hyatt Pumping-Generating Plant is the largest of the three power plants with a capacity of 645 MW. Water from the six-unit underground power plant (three conventional generating and three pumping-generating units) is discharged through two tunnels into the Feather River just downstream of Oroville Dam. The plant has a generating and pumping flow capacity of 16,950 cfs and

5,610 cfs, respectively. Other generation facilities include the 3-MW Thermalito Diversion Dam Power Plant and the 114-MW Thermalito Pumping-Generating Plant.

Thermalito Diversion Dam, four miles downstream of the Oroville Dam creates a tail water pool for the Hyatt Pumping-Generating Plant and is used to divert water to the Thermalito Power Canal. The Thermalito Diversion Dam Power Plant is a 3-MW power plant located on the left abutment of the Diversion Dam. The power plant releases a maximum of 615 cubic feet per second (cfs) of water into the river.

The Power Canal is a 10,000-foot-long channel designed to convey generating flows of 16,900 cfs to the Thermalito Forebay and pump-back flows to the Hyatt Pumping-Generating Plant. The Thermalito Forebay is an off-stream regulating reservoir for the 114-MW Thermalito Pumping-Generating Plant. The Thermalito Pumping-Generating Plant is designed to operate in tandem with the Hyatt Pumping-Generating Plant and has generating and pump-back flow capacities of 17,400 cfs and 9,120 cfs, respectively. When in generating mode, the Thermalito Pumping-Generating Plant discharges into the Thermalito Afterbay, which is contained by a 42,000-foot-long earth-fill dam. The Afterbay is used to release water into the Feather River downstream of the Oroville Facilities, helps regulate the power system, provides storage for pump-back operations, and provides recreational opportunities. Several local irrigation districts receive water from the Afterbay.

The Feather River Fish Barrier Dam is downstream of the Thermalito Diversion Dam and immediately upstream of the Feather River Fish Hatchery. The flow over the dam maintains fish habitat in the low-flow channel of the Feather River between the dam and the Afterbay outlet, and provides attraction flow for the hatchery. The hatchery was intended to compensate for spawning grounds lost to returning salmon and steelhead trout from the construction of Oroville Dam. The hatchery can accommodate an average of 15,000 to 20,000 adult fish annually.

The Oroville Facilities support a wide variety of recreational opportunities. They include: boating (several types), fishing (several types), fully developed and primitive camping (including boat-in and floating sites), picnicking, swimming, horseback riding, hiking, off-road bicycle riding, wildlife watching, hunting, and visitor information sites with cultural and informational displays about the developed facilities and the natural environment. There are major recreation facilities at Loafer Creek, Bidwell Canyon, the Spillway, North and South Thermalito Forebay, and Lime Saddle. Lake Oroville has two full-service marinas, five car-top boat launch ramps, ten floating campsites, and seven dispersed floating toilets. There are also recreation facilities at the Visitor Center and the OWA.

The OWA comprises approximately 11,000-acres west of Oroville that is managed for wildlife habitat and recreational activities. It includes the Thermalito Afterbay and surrounding lands (approximately 6,000 acres) along with 5,000 acres adjoining the

Feather River. The 5,000 acre area straddles 12 miles of the Feather River, which includes willow and cottonwood lined ponds, islands, and channels. Recreation areas include dispersed recreation (hunting, fishing, and bird watching), plus recreation at developed sites, including Monument Hill day use area, model airplane grounds, three boat launches on the Afterbay and two on the river, and two primitive camping areas. California Department of Fish and Game's (DFG) habitat enhancement program includes a wood duck nest-box program and dry land farming for nesting cover and improved wildlife forage. Limited gravel extraction also occurs in a number of locations.

1.3 CURRENT OPERATIONAL CONSTRAINTS

Operation of the Oroville Facilities varies seasonally, weekly and hourly, depending on hydrology and the objectives DWR is trying to meet. Typically, releases to the Feather River are managed to conserve water while meeting a variety of water delivery requirements, including flow, temperature, fisheries, recreation, diversion and water quality. Lake Oroville stores winter and spring runoff for release to the Feather River as necessary for project purposes. Meeting the water supply objectives of the SWP has always been the primary consideration for determining Oroville Facilities operation (within the regulatory constraints specified for flood control, in-stream fisheries, and downstream uses). Power production is scheduled within the boundaries specified by the water operations criteria noted above. Annual operations planning is conducted for multi-year carry over. The current methodology is to retain half of the Lake Oroville storage above a specific level for subsequent years. Currently, that level has been established at 1,000,000 acre-feet (af); however, this does not limit draw down of the reservoir below that level. If hydrology is drier than expected or requirements greater than expected, additional water would be released from Lake Oroville. The operations plan is updated regularly to reflect changes in hydrology and downstream operations. Typically, Lake Oroville is filled to its maximum annual level of up to 900 feet above mean sea level (msl) in June and then can be lowered as necessary to meet downstream requirements, to its minimum level in December or January. During drier years, the lake may be drawn down more and may not fill to the desired levels the following spring. Project operations are directly constrained by downstream operational constraints and flood management criteria as described below.

1.3.1 Downstream Operation

An August 1983 agreement between DWR and DFG entitled, "Agreement Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish & Wildlife," sets criteria and objectives for flow and temperatures in the low flow channel and the reach of the Feather River between Thermalito Afterbay and Verona. This agreement: (1) establishes minimum flows between Thermalito Afterbay Outlet and Verona which vary by water year type; (2) requires flow changes under 2,500 cfs to be reduced by no more than 200 cfs during any 24-hour period, except for flood management, failures, etc.; (3) requires flow stability during the peak of the fall-run

Chinook spawning season; and (4) sets an objective of suitable temperature conditions during the fall months for salmon and during the later spring/summer for shad and striped bass.

1.3.1.1 Instream Flow Requirements

The Oroville Facilities are operated to meet minimum flows in the Lower Feather River as established by the 1983 agreement (see above). The agreement specifies that Oroville Facilities release a minimum of 600 cfs into the Feather River from the Thermalito Diversion Dam for fisheries purposes. This is the total volume of flows from the diversion dam outlet, diversion dam power plant, and the Feather River Fish Hatchery pipeline.

Generally, the instream flow requirements below Thermalito Afterbay are 1,700 cfs from October through March, and 1,000 cfs from April through September. However, if runoff for the previous April through July period is less than 1,942,000 af (i.e., the 1911-1960 mean unimpaired runoff near Oroville), the minimum flow can be reduced to 1,200 cfs from October to February, and 1,000 cfs for March. A maximum flow of 2,500 cfs is maintained from October 15 through November 30 to prevent spawning in overbank areas that might become de-watered.

1.3.1.2 Temperature Requirements

The Diversion Pool provides the water supply for the Feather River Fish Hatchery. The hatchery objectives are 52°F for September, 51°F for October and November, 55°F for December through March, 51°F for April through May 15, 55°F for last half of May, 56°F for June 1-15, 60°F for June 16 through August 15, and 58°F for August 16-31. A temperature range of plus or minus 4°F is allowed for objectives, April through November.

There are several temperature objectives for the Feather River downstream of the Afterbay Outlet. During the fall months, after September 15, the temperatures must be suitable for fall-run Chinook. From May through August, they must be suitable for shad, striped bass, and other warmwater fish.

The National Marine Fisheries Service has also established an explicit criterion for steelhead trout and spring-run Chinook salmon. Memorialized in a biological opinion on the effects of the Central Valley Project and SWP on Central Valley spring-run Chinook and steelhead as a reasonable and prudent measure; DWR is required to control water temperature at Feather River mile 61.6 (Robinson's Riffle in the low-flow channel) from June 1 through September 30. This measure requires water temperatures less than or equal to 65°F on a daily average. The requirement is not intended to preclude pump-back operations at the Oroville Facilities needed to assist the State of California with supplying energy during periods when the California ISO anticipates a Stage 2 or higher alert.

The hatchery and river water temperature objectives sometimes conflict with temperatures desired by agricultural diverters. Under existing agreements, DWR provides water for the Feather River Service Area (FRSA) contractors. The contractors claim a need for warmer water during spring and summer for rice germination and growth (i.e., 65°F from approximately April through mid May, and 59°F during the remainder of the growing season). There is no obligation for DWR to meet the rice water temperature goals. However, to the extent practical, DWR does use its operational flexibility to accommodate the FRSA contractor's temperature goals.

1.3.1.3 Water Diversions

Monthly irrigation diversions of up to 190,000 (July 2002) af are made from the Thermalito Complex during the May through August irrigation season. Total annual entitlement of the Butte and Sutter County agricultural users is approximately 1 maf. After meeting these local demands, flows into the lower Feather River continue into the Sacramento River and into the Sacramento-San Joaquin Delta. In the northwestern portion of the Delta, water is pumped into the North Bay Aqueduct. In the south Delta, water is diverted into Clifton Court Forebay where the water is stored until it is pumped into the California Aqueduct.

1.3.1.4 Water Quality

Flows through the Delta are maintained to meet Bay-Delta water quality standards arising from DWR's water rights permits. These standards are designed to meet several water quality objectives such as salinity, Delta outflow, river flows, and export limits. The purpose of these objectives is to attain the highest water quality, which is reasonable, considering all demands being made on the Bay-Delta waters. In particular, they protect a wide range of fish and wildlife including Chinook salmon, Delta smelt, striped bass, and the habitat of estuarine-dependent species.

1.3.2 Flood Management

The Oroville Facilities are an integral component of the flood management system for the Sacramento Valley. During the wintertime, the Oroville Facilities are operated under flood control requirements specified by the U.S. Army Corps of Engineers (USACE). Under these requirements, Lake Oroville is operated to maintain up to 750,000 af of storage space to allow for the capture of significant inflows. Flood control releases are based on the release schedule in the flood control diagram or the emergency spillway release diagram prepared by the USACE, whichever requires the greater release. Decisions regarding such releases are made in consultation with the USACE.

The flood control requirements are designed for multiple use of reservoir space. During times when flood management space is not required to accomplish flood management objectives, the reservoir space can be used for storing water. From October through March, the maximum allowable storage limit (point at which specific flood release would have to be made) varies from about 2.8 to 3.2 maf to ensure adequate space in Lake Oroville to handle flood flows. The actual encroachment demarcation is based on a wetness index, computed from accumulated basin precipitation. This allows higher levels in the reservoir when the prevailing hydrology is dry while maintaining adequate flood protection. When the wetness index is high in the basin (i.e., wetness in the watershed above Lake Oroville), the flood management space required is at its greatest amount to provide the necessary flood protection. From April through June, the maximum allowable storage limit is increased as the flooding potential decreases, which allows capture of the higher spring flows for use later in the year. During September, the maximum allowable storage decreases again to prepare for the next flood season. During flood events, actual storage may encroach into the flood reservation zone to prevent or minimize downstream flooding along the Feather River.

2.0 NEED FOR STUDY

Fish species and habitat distributions in the Feather River have the potential to be affected by operations of the Oroville Facilities. Evaluation of potential relationships between operations of the Oroville Facilities and the quality, quantity, and distribution of fish species and their habitats in the Feather River requires, in part, current baseline information on fish distribution.

As a task of SP-F3.2, *Evaluation of Project Effects on Non-salmonid Fish in the Feather River Downstream of the Thermalito Diversion Dam*, Task 4 fulfills a portion of the FERC application requirements by identifying fish habitat in the Feather River from the Thermalito Diversion Dam to the confluence of the Sacramento and Feather rivers, as it pertains to species-specific habitat requirements. Task 5 evaluates the potential project effects on non-salmonid fish species, and integrates fish species distribution information and habitat requirements. Performing this study is necessary, in part, because operations of the Oroville Facilities affect the flow, stage, substrate, instream cover, and water temperature in the Feather River and the flow, stage, substrate, instream cover complexity, and water temperature regimes in the Feather River influence mesohabitat type proportion and distribution, and fish species spatial and temporal distribution and relative abundance. In addition to fulfilling statutory requirements, information collected as part of this task may be used in developing or evaluating potential Resource Actions.

3.0 STUDY OBJECTIVES

3.1 APPLICATION OF STUDY INFORMATION

The purpose of SP-F3.2 Task 4 is to identify fish habitat in the Feather River from the Thermalito Diversion Dam to the confluence of the Sacramento and Feather rivers, as it pertains to species-specific habitat requirements, and the purpose of Task 5, is to evaluate the potential project effects on non-salmonid fish species, and integrate fish species distribution information and habitat requirements. Data collected in this task also serves as a foundation for future evaluations and development of potential Resource Actions.

3.1.1 Department of Water Resources/Stakeholders

The information from this analysis will be used by DWR and the Environmental Work Group (EWG) to evaluate potential project effects on mesohabitat suitability and fish species relative abundance. Additionally, data collected in this task serves as a foundation for future evaluations and development of potential Resource Actions.

3.1.2 Other Studies

As a task associated with study plan (SP)-F3.2, *Evaluation of Project Effects on Non-salmonid Fish in the Feather River Downstream of the Thermalito Diversion Dam,* Task 4, identifies fish habitat in the Feather River from the Thermalito Diversion Dam to the Sacramento River confluence, as it pertains to species-specific habitat requirements, and Task 5 evaluates the potential project effects on non-salmonid fish species, and integrates fish species distribution information and habitat requirements. For further description of Tasks 4 and 5 see SP-F3.2 and associated interim and final reports.

3.1.4 Environmental Documentation

In addition to Section 4.51(f)(3) of 18 CFR, which requires reporting of certain types of information in the Federal Energy Regulatory Commission (FERC) application for license of major hydropower projects (FERC 2001), it may be necessary to satisfy the requirements of the National Environmental Policy Act (NEPA). Because FERC has the authority to grant an operating license to DWR for continued operation of the Oroville Facilities, discussion is required to identify the potential impacts of the project on many types of resources, including fish, wildlife, and botanical resources. In addition, NEPA requires discussion of any anticipated continuing impact from on-going and future operations. To satisfy NEPA, DWR is preparing a Preliminary Draft Environmental Assessment (PDEA) to attach to the FERC license application, which shall include information provided by this study plan report.

3.1.5 Settlement Agreement

In addition to statutory and regulatory requirements, SP-F3.2 Task 1, 4, 5 could provide information to aid in the development of potential Resource Actions to be negotiated during the collaborative process.

4.0 METHODOLOGY

4.1 FISH DISTRIBUTION

4.1.1 Data Collection

Fish distribution information was developed utilizing three distinctly different methods, each with their own strengths and weaknesses, including differences in the quality and quantity of data as well as temporal and spatial resolution of fish distribution information. Fish distribution data collection methods included snorkel surveys, rotary screw trapping, and seining. Data sets were combined to provide the most comprehensive set of the temporal, spatial, and relative abundance information available to characterize fish species distribution by life stage in the lower Feather River.

4.1.1.1 Snorkel Survey

Snorkel surveys typically involve one or more snorkelers swimming in a water body while counting fish. Snorkeling requires the least amount of equipment of all underwater observation techniques and is one of the simplest ways to observe organisms underwater. Equipment typically includes a mask, snorkel, wet or dry suit, and swim fins or wading boots, depending on the depth and width of the river being investigated. Small streams and rivers normally are well suited for snorkel observations provided underwater visibility is adequate (Dolloff and Reeves 1990).

Snorkeling techniques vary depending on the study objectives and environment to be surveyed. In flowing waters, divers moving upstream are less likely to startle fish and cause them to flee or change their behavior because most stream-dwelling fish orient facing into the current. Whenever conditions permit (i.e. low flows and shallow water), divers should enter streams downstream from the unit to be sampled and proceed slowly upstream pulling themselves along the bottom being careful to avoid sudden movements. When it is impractical or too deep to move upstream, divers should enter the water upstream from the sampling unit and float downstream with the current, remaining as motionless as possible. Size and complexity of the sampled unit, underwater visibility, and the survey objectives determine the number of observers needed to complete a particular survey. Snorkelers often are followed by a recorder who rafts behind them and records data (Dolloff and Reeves 1990).

DWR performed snorkel surveys in the Lower Feather River during May 1999, June 2000, and May 2001. Number of fish, size (total length), and habitat (i.e., substrate, cover, and mesohabitat type unit) were recorded. Water temperature and weather conditions also were measured and recorded during the study. Snorkeling observations were made in a downstream direction, with three to six snorkelers divided among three transects (i.e., left bank, right bank, and center channel) (DWR 2004a).

Snorkel surveys were conducted at three spatial scales: broad, intermediate, and fine. Broad scale surveys were performed from near the Fish Barrier Dam (RM 67.4) to Gridley Bridge (RM 50.8) covering approximately 15.5 miles (25 km) and occurred only once per year (Figure 4.1-1). Broad-scale surveys were completed annually in 1999, 2000, and 2001. The 1999 survey was conducted from May 13 to May 26; the 2000 survey was conducted from June 5 to June 20; and the 2001 survey was conducted from May 1 to May 10. The broad scale surveys provided a snapshot of overall abundance and distribution of fishes in the lower Feather River, and provided observations in areas or habitats not covered at smaller scales. The intermediate-scale surveys occurred once a month from March through August during each study year from 1999 through 2001 at nine permanent snorkeling sites covering between 984 linear ft and 1684 linear ft (300-500 m) at each site all with at least one riffle-pool sequence (Figure 4.1-1). Six of the snorkeling sites were located between the Fish Barrier Dam and the Thermalito Afterbay Outlet, while the remaining three sites were located between the Thermalito Afterbay Outlet and Honcut Creek. Intermediate scale snorkel surveys provided information regarding both the temporal and geographic distribution of a variety of fish species in the Feather River. Fine-scale snorkel surveys occurred at 24 locations, each approximately 82 ft (25 m) in length, monthly from March through August in 2001 and 2002 (DWR 2004a).

Snorkel observations in the broad and intermediate scale surveys generally were made in a downstream direction. Three to six divers were distributed among three transects: left bank, right bank, and center channel. Divers used plastic dive slates to mark information on individual fish or schools of fish. Groups of similar sized fish that were observed in a one square meter or less area were treated as a single observation. Snorkel survey data recorded included: the approximate fish size (mm fork length(FL)), number of fish, substrate type, cover, and mesohabitat type. Fish identification and size estimation by divers was verified and calibrated by training with tethered fishes in a controlled setting, and also by oversight of experienced divers. Size estimation also was aided by comparing observed fishes to nearby objects, which could be measured using the scale provided on plastic writing slates. Effort at each sampling site was recorded in terms of the time sampled, area covered, and the number of divers utilized (DWR 2004a).

Fine-scale surveys were completed somewhat differently than the broad and intermediate scale surveys. Twenty-four sampling locations were selected at random and sampled each month. Twelve sampling locations were in the LFC and twelve locations were in the HFC. Each section covered an area 82 ft (25 m) long and 13 ft (4 m) wide and ran parallel to one riverbank (Figures 4.1-1 and 4.1-2). Two divers surveyed the reach by working upstream and marking the number, species, size and position of all fishes observed. After the fish survey was complete, divers recorded water depth, average velocity, substrate, cover and habitat type at 36 points, each representing a one square meter cell within the reach. Fish observations were recorded by their association with these one-square meter cells. Depth and focal velocity were also recorded for each fish observation (DWR 2004a).

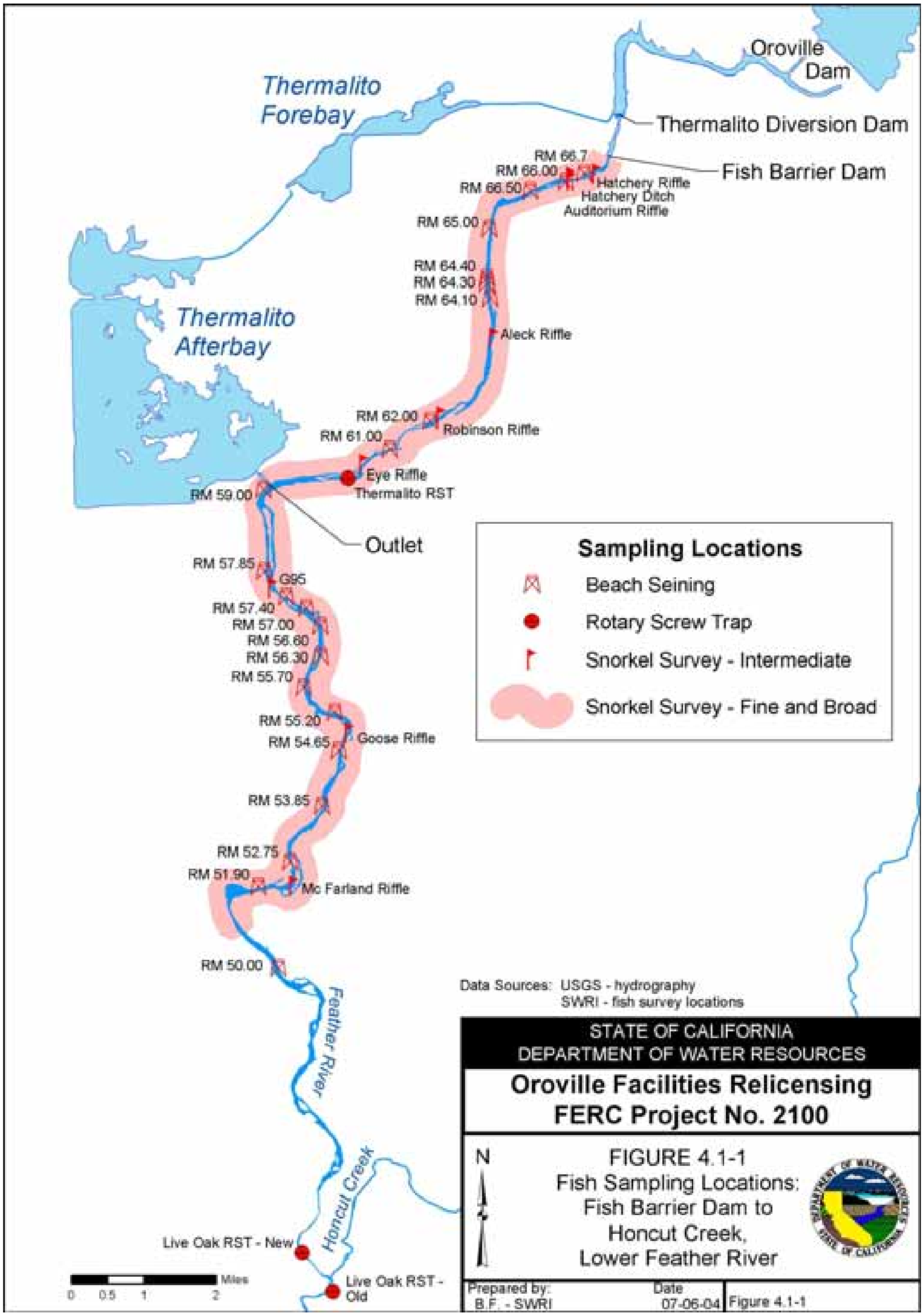


Figure 4.1-1. Fish sampling locations from Fish Barrier Dam to Honcut Creek, Lower Feather River.

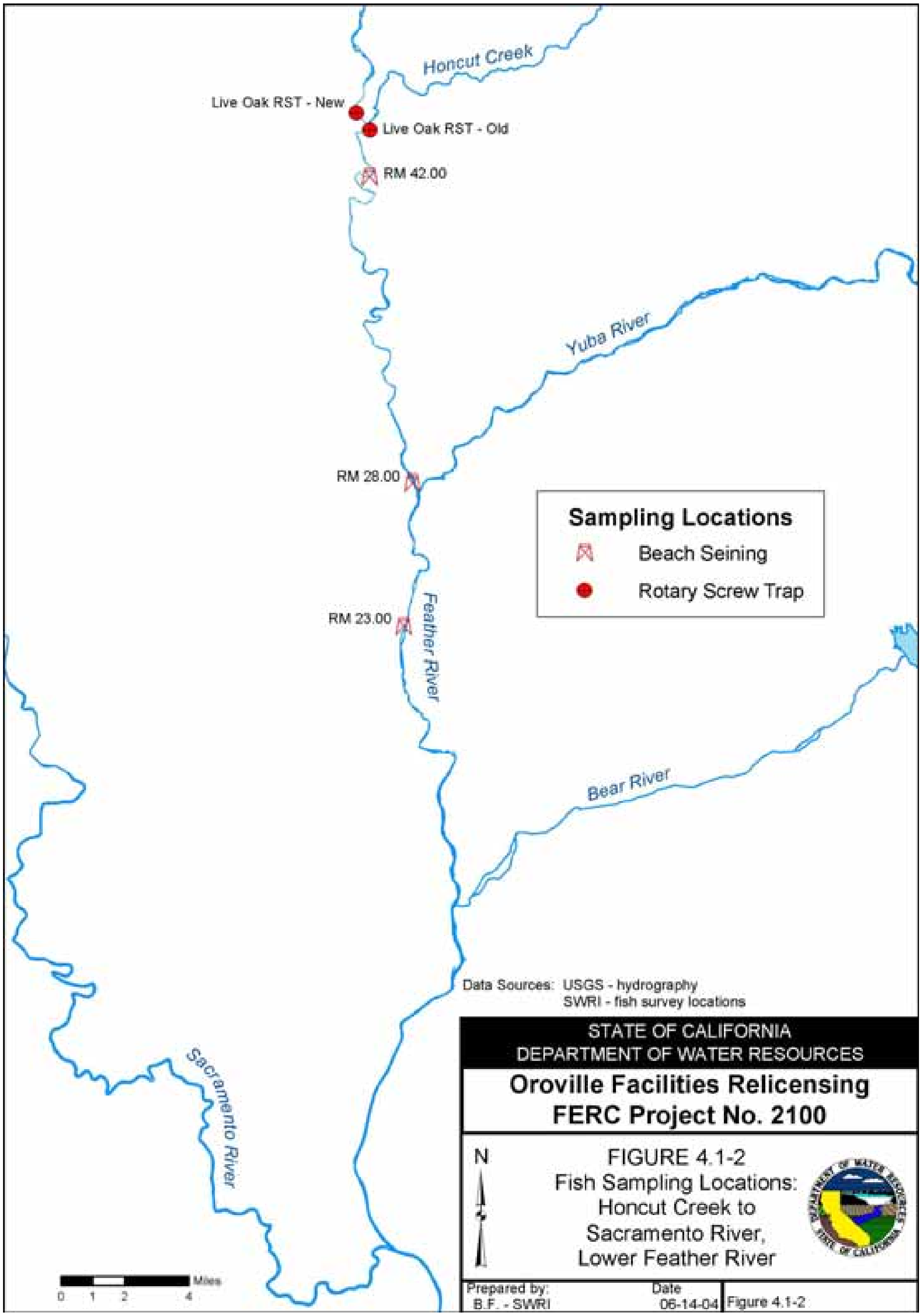


Figure 4.1-2. Fish sampling locations from Honcut Creek to the confluence with the Sacramento River, Lower Feather River.

4.1.1.2 Rotary Screw Trap Survey

DWR currently uses rotary screw traps (RST's) to monitor fish populations in the lower Feather River. The traps are designed to float in the main channel and capture fish moving downstream. Data gathered from RST's provides valuable information on fish populations. RST's in the lower Feather River consist of a rotating cone, measuring eight feet in diameter, positioned between two pontoons that float the entire trap. Lowering the trapping cone into the river channel until it is submerged approximately half way enables operation of the trap. Water flows into the cone striking baffles, causing rotation of the cone. Fish enter at the upstream end of the rotating trapping cone and are conveyed to a live box where they are held for data gathering. Rotary screw traps are deployed in the lower Feather River because they are sturdy, relatively easy to move within the stream, easy to operate and maintain, are able to capture fish with relatively little harm in fast-moving water, and can be used to sample continuously (DWR 2002b).

From December 1998 through June 2001, DWR sampled the lower Feather River using two RST's. The Thermalito RST was stationed at RM 60.1, upstream from the Thermalito Afterbay Outlet. The Live Oak RST was stationed at RM 42, downstream from the confluence with Honcut Creek (Figures 4.1-1 and 4.1-2). The RSTs primarily are designed for estimating the number of emigrating juvenile salmonids, including Chinook salmon and steelhead, but other species also are caught in the RSTs. Chinook salmon are the dominant species caught in the RSTs, comprising over 99 percent of the catch. Data from RSTs primarily serve to provide information regarding the temporal and geographic distribution of juvenile salmonids and the environmental factors that influence juvenile emigration timing (DWR 2002b; Seesholtz et al. 2003).

RST capture efficiencies can be affected by several biotic and abiotic factors, including the size distribution of fish, and water velocities. For example, the Live Oak RST reportedly has been ineffective at catching larger fish at low flows (1,000-1,500 cfs) (DWR 2002b).

4.1.1.3 Seine Surveys

Seining is a method of trapping fish by encircling them in a fencelike wall of netting. Seines have a float line suspended on the water surface and a lead line that is attached to weights, which allows the net to form the desired wall of webbing. Many seines also have a specially constructed bag into which the fish are concentrated as the net is hauled. Variations of the seine include: beach seines, haul seines, and purse seines. Beach or haul seines are typically used in shallow water where the net wall extends from the surface to the substrate and are most effective for nearshore fish species. Beach seines can be hauled by either one or two vessels or people (Hayes et al. 1996). Purse seining captures fish near the surface by encircling the fish with a deep curtain of netting supported at the surface by floats. The seine is closed by "pursing" the bottom of the net by tightening a line that is run through rings attached to the bottom edge of the seine. Tightening the subsurface line slowly closes the bottom of the seine, which keeps the fish from diving out of the net. Purse seining typically is used as a method of catching schools of fish by boat. When the seine is closed, the fishing crew hoists the net above the boat in order to release the catch (Hayes et al. 1996).

DWR conducted seining surveys in the Lower Feather River between January 1997 and August 2001 to document fish distribution and relative abundance. The study area included the reach of the Feather River extending from the Fish Barrier Dam to the Thermalito Afterbay Outlet and the reach extending from the Thermalito Afterbay Outlet to Boyd's pump (Figure 4.1.2). Two methods of seining were used for the study: purse seining was used at boat ramps and beach seining was used for open and moving water habitats, such as riffles and glides. In both methods, all fish were removed from the seine and put into a five-gallon bucket of water for species identification and enumeration. Seining was not used to obtain quantitative estimates of individual species (DWR 2002a; Seesholtz et al. 2003).

Although seining can be an effective tool for use in enumerating studies, it is limited to shallow water with a fairly uniform bottom and low water velocities. Additionally, seining would not be feasible in areas with woody debris, which could snag nets and release fish. Seining also is typically used in a closed system for quantitative estimates of fish populations (Parsley et al. 1989). It is difficult to obtain accurate quantitative enumeration estimates via seining in an open system, such as a river, because fish move in and out of the system. Additionally, seining does not allow for continuous sampling because the seine must be hauled through the water each time a sample is collected.

4.1.1.4 Creel Survey

The geographic units in which the creel survey results were reported were inconsistent among sample years. Therefore, creel survey data were not utilized in the development of the fish distribution or relative abundance for the lower Feather River.

4.1.2 Generalized Representation of Fish Distribution and Relative Abundance

A relative range of fish species distribution data are presented rather than an explicit representation of individual species distribution data. The abundance of individuals within each species classified as "Frequently Observed" or "Infrequently Observed" is relative only within species. For example, e.g., "Frequently Observed" hitch does not mean that the number of hitch observed is of the same order of magnitude as "Frequently Observed" Sacramento pikeminnow. The designation of "Frequently Observed" (highlighted dark blue on Figures 5.1-1 to 5.1-23) is used to characterize those areas in which individuals within each species are most commonly observed in the greatest numbers. The designation "Infrequently Observed" (highlighted red on

Figures 5.1-1 to 5.1-23) refers to those areas in which individuals within each species typically are observed less frequently, less consistently, or in lower numbers than in those areas designated “Frequently Observed.” “Not Present” (highlighted light blue on Figures 5.1-1 to 5.1-23) means that the species or life stage was not found.

4.2 FISH HABITAT COMPONENTS

The development of the geographic distribution of fish habitat required compilation of the combination of habitat components required by each species and life stage. The habitat components available for evaluation to identify potential fish habitat included: mesohabitat type, substrate type, water depth, and water temperature. Geographic information systems (GIS) are information integration and analysis tools that are beneficial to the scientific study and management of riverine fishery resources. GIS integrates the combination of habitat component attributes for a specific fish species and life stage to identify areas with a combination of attributes that simultaneously meet the fish species and life stage habitat requirements. Additionally GIS could be used to compare fish species and habitat distributions to aid in management decision-making.

4.2.1 Mesohabitat

Mesohabitat units are distinct areas of stream defined by similar physical characteristics (e.g., slope, width, depth, and substrate). The polygon area in the GIS defined with the mesohabitat type was attributed with representative characterizations of substrate type, water depth, cover, and habitat complexity. Mesohabitat units are the basic geographic unit of the GIS fish habitat queries.

4.2.1.1 Mesohabitat Classifications

The U.S. Forest Service developed the stream mesohabitat classification systems used in this analysis. Six mesohabitat types were recorded in the lower Feather River mesohabitat survey including: riffle, run, glide, pool, boulder run, and backwater.

Riffles typically are fairly shallow with relatively fast flowing water moves over rocks or uneven bedrock substrate. Riffles are characterized by relatively high gradients with substrate of large gravel and/or cobble, above average water velocities, below average depth, surface turbulence and are channel controlled (i.e., no backwater influence).

Runs typically are deeper than riffles with turbulent flow over an uneven substrate. Runs are characterized by moderate gradients with small gravel and/or cobble substrates, above average water velocities, average depth, low to moderate turbulences, are channel controlled, and generally are associated with the downstream extent of riffles. A run is a swiftly flowing stream reach with little surface agitation and no major flow obstructions. Flooded riffles often appear as runs.

Glides typically are characterized by relatively low gradients with small gravel and/or silt/sand substrates, below average water velocities, below average depth, no turbulence, variable control, and generally are associated with the tails of pools and heads of riffles.

Pools typically are characterized by a relatively low gradient with fine substrates, below average water velocities, below average turbulence, above average depth, and are generally section controlled. Pools do not show much, if any, current at the surface.

Backwater mesohabitat exhibit backed-up or retarded flows in comparison to normal downstream flow, or a ponding of a stream above an unnatural constriction. Backwaters generally tend to be out of the main channel flow and can exhibit negative velocities (i.e., upstream flow).

4.2.1.2 Data Collection

DWR (SP-G2) determined mesohabitat types by conducting field surveys and delineating mesohabitat units on digital orthophoto quarter-quadrangles (DOQQs) from 2001. DOQQs are digital images derived from scanned aerial photographs that are rectified to remove image geometric distortions caused by camera orientation or terrain relief. The DOQQs were created from source images taken in 1998 and 1999 and have a 1-meter ground resolution. DOQQs must meet horizontal National Map Accuracy Standards (NMAS) at 1:12,000 scale, which specify that 90 percent of the well-defined points tested must fall within an absolute positional accuracy of 33.3 feet (1/30 inch).

Cross-section surveys were conducted from March through August 2002 (SP-G2). Prints of the DOQQ orthophotos were delineated with mesohabitat unit boundaries and classified by DWR geologists while conducting a boat survey on the lower Feather River. Positional reference was provided by a differential GPS unit and through visual orientation by observation of features on the ground compared to the aerial photograph map base. Assignment of the mesohabitat classification was based on the professional judgment of the DWR geologists by matching the observed conditions at the time of the survey to the closest mesohabitat classification definition.

4.2.2 Substrate

The term substrate refers to a surface that includes the mineral and/or organic material comprising the streambed or the surfaces on which plants or animals could attach. The character of the riverine substrates is important to physical, chemical, and biological river functions, which determine mesohabitat suitability for different fish species and life stages.

4.2.2.1 Substrate classification

Five substrate types were recorded during the survey, including: bedrock, boulder, cobble, gravel, sand, and silt/clay. Bedrock substrate is characterized by exposed solid rock layers. Boulder substrate is defined as the largest rock able to be transported by a stream. Boulders typically are larger than 10 inches (25.6 cm) in diameter. Cobble substrate is smaller than boulder and larger than gravel, and was arbitrarily defined to be from 2.5 inches to 10 inches in diameter. Gravel substrate consists of particles between 2 mm and 64 mm (0.08 and 2.5 inches) in diameter and is larger than sand and smaller than cobble. Sand substrate particles are 0.062 mm to 2 mm (0.002 to 0.2 inches) in diameter and are more coarse than silt and finer than gravel. Silt particles are 0.004 mm to 0.062 mm (0.00016 to 0.002 inches) in diameter. Clay particles are generally smaller than 0.004 mm in diameter (DFG 2002a).

4.2.2.2 Data Collection

DWR (SP-G2) determined substrate by collecting grab samples and using visual observations during the mesohabitat survey to characterize the general substrate conditions in each mesohabitat survey unit.

4.2.3 Water Depth

Water depth is an important physical variable that could play a role in determining fish community composition. Water depth is particularly important to the juvenile and spawning life stages of some species.

4.2.3.1 Water Depth Classification

Water depth strata were defined in 2-foot intervals. Shallow-water included water strata from zero to two feet deep, mid-water depths comprised from 2.1 to four feet deep and from 4.1 to six feet, and deep-water strata included all depths greater than 6.1 feet.

4.2.3.2 Data Collection

DWR (SP-G2) estimated the average depth of each mesohabitat unit based on USGS 2-foot contour data (DWR 2004b).

4.2.4 Instream Cover Complexity

Areas that offer aquatic organisms protection from predators or competitors were considered to be areas in which cover existed. Instream cover complexity was determined by the amount and type (i.e., boulders, undercut banks, woody debris) of available cover within each habitat unit.

4.2.4.1 Classification of instream cover complexity

DWR geologists classified instream cover complexity during the mesohabitat surveys. Qualitative classifications of none, low, medium, and high cover complexity were assigned to areas depending upon the relative amount of large woody debris, overhanging vegetation, submerged vegetation, undercut banks, and predator refuges present (Table 4.2-1).

Table 4.2-1. Instream cover complexity classification system.

Code	Cover description
None	No apparent cover
SIO	Small – Medium instream objects/woody debris (< 31 cm or 1 ft. diameter)
LIO	Large instream objects/woody debris (> 31 cm or 1 ft. diameter)
OvOb	Overhead objects
SAV	Submerged aquatic vegetation
UB	Undercut bank

Data Collection

DWR (SP-G2) visually estimated the instream cover complexity of each mesohabitat unit during the mesohabitat surveys. Each mesohabitat unit was assigned an instream cover complexity classification based on the relative amount of cover compared to other river reaches. DWR geologists utilized best professional judgment to assess instream cover complexity (DWR 2004b).

4.2.5 Water Temperature

Water temperature is a physical environmental variable that plays a primary role in determining fish community composition and relative abundance of species and life stages.

4.2.5.1 Water Temperature Classification

Because thermal requirements and tolerances vary for different fish species and life stages, no single classification for water temperature was utilized in this analysis.

4.2.5.2 Data Collection

DWR (SP-W6) collected water temperatures from 24 water temperature data loggers (thermographs) located in the lower Feather River, from immediately below the Thermalito Diversion Dam to the confluence with the Sacramento River. The data loggers usually collected water temperature data every fifteen minutes and generally were located in or near riffle mesohabitat types. Geographic coordinates of loggers' locations were collected by differential GPS.

4.2.6 Water Quality Exceedances of Aquatic Life Criteria

Information on the water quality of many rivers and streams is collected by a number of agencies for their own use as well as for public dissemination. The data gathered from these programs typically are used to detect exceedance of water quality criteria and to generally manage water quality. Water bodies provide many environmental values, including recreation, irrigation, stock watering, and fish and wildlife habitat.

Environmental water quality usually is assessed against a criterion or guideline for each separate chemical or physical variable. These guidelines generally take into account regional variations of water quality, baseline environmental conditions, and typically allow for variation in the parameters measured and frequency of measurement for each water body. Guidelines are chosen based on the primary management goals for a water body.

4.2.6.1 Water Quality Exceedances Classification

The National Ambient Water Quality Criteria (NAWQC) are applicable regulatory standards that are calculated by the EPA as half the Final Acute Value (FAV), which is the fifth percentile of the distribution of 48 to 96-hour LC50 (lethal concentration that kills 50 percent of test animals in a given time) values or equivalent median effective concentration (EC50) values for each chemical criterion (EPA 2002). The acute NAWQC are intended to correspond to concentrations that would cause less than 50% mortality in 5% of exposed populations in a brief exposure. The chronic NAWQC are the FAVs divided by the Final Acute-Chronic Ratio (FAC), which is the geometric mean of quotients of at least three LC50/CV ratios from tests of different families of aquatic organisms (EPA 2002).

On May 18, 2000 EPA published 40 CFR 131, *Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California*, generally known as the California Toxics Rule (CTR). EPA has promulgated numeric water quality criteria for priority toxic pollutants and other provisions for water quality standards to be applied to waters in the state of California. These federal criteria are legally applicable in the state of California for inland surface waters, enclosed bays, and estuaries for all purposes and programs under the Clean Water Act.

4.2.6.2 Data Collection

DWR used the "clean hands/dirty hands" method of water sampling for metals described by EPA (EPA 1996). The laboratory (either Frontier Geosciences or DWR's Bryte Chemical Laboratory) supplied acid cleaned bottles double wrapped in polyethylene ziplock bags. Wearing gloves, one person opened the outer bag, while the second person opened the inner bag, removed the sample container, filled the container with sample water by dipping, immediately capped the container, placed the container back in inner bag, and sealed the inner bag, after which the first person sealed the outer bag and placed the doubled bagged sample in an ice chest. Samples were acidified and filtered, as necessary, in the laboratory.

Samples for toxicity were collected by dipping a 5-gallon carboy supplied by the laboratory into the river. After filling, the bucket was placed on ice in an ice chest and delivered to Pacific EcoRisk laboratory for analysis within 24 hours of collection. See Figures 4.2-1 and 4.2-2 show the water quality sampling locations in the lower Feather River.

4.2.7 Dissolved Oxygen

Physiological tolerances of different fish species and life stages to dissolved oxygen (DO) concentrations determine, in part, the fish community composition and dynamics. Depending on the test method, life stage, and water temperature (cold or warm), EPA DO concentration criteria can be as low as 3.0 mg/L (1-day minimum for warm-water species adult life stages) or as high as 9.5 mg/L (7-day mean for inter-gravel water to protect cold-water species early life stages). Stricter limits were established by EPA for cold water systems because salmonids reportedly have greater sensitivities to low DO concentration conditions (Moyle 2002).

4.2.7.1 Classification

EPA reports that the thirty-day mean water column dissolved oxygen concentration for protection of adult life stages of coldwater fish species is 6.5 mg/L (EPA 2002). The thirty-day mean DO concentration criterion was used because it is the most protective value provided for post-juvenile life stages. Single-day minimum (4.0 mg/L) and seven-day mean minimum (3.0 mg/L) criteria were both less protective than the thirty-day mean value provided by EPA as a minimum dissolved oxygen concentration suitable for coldwater aquatic life (EPA 2002). Therefore, for the purpose of this analysis, dissolved oxygen concentrations exceeding 6.5 mg/L were considered suitable.

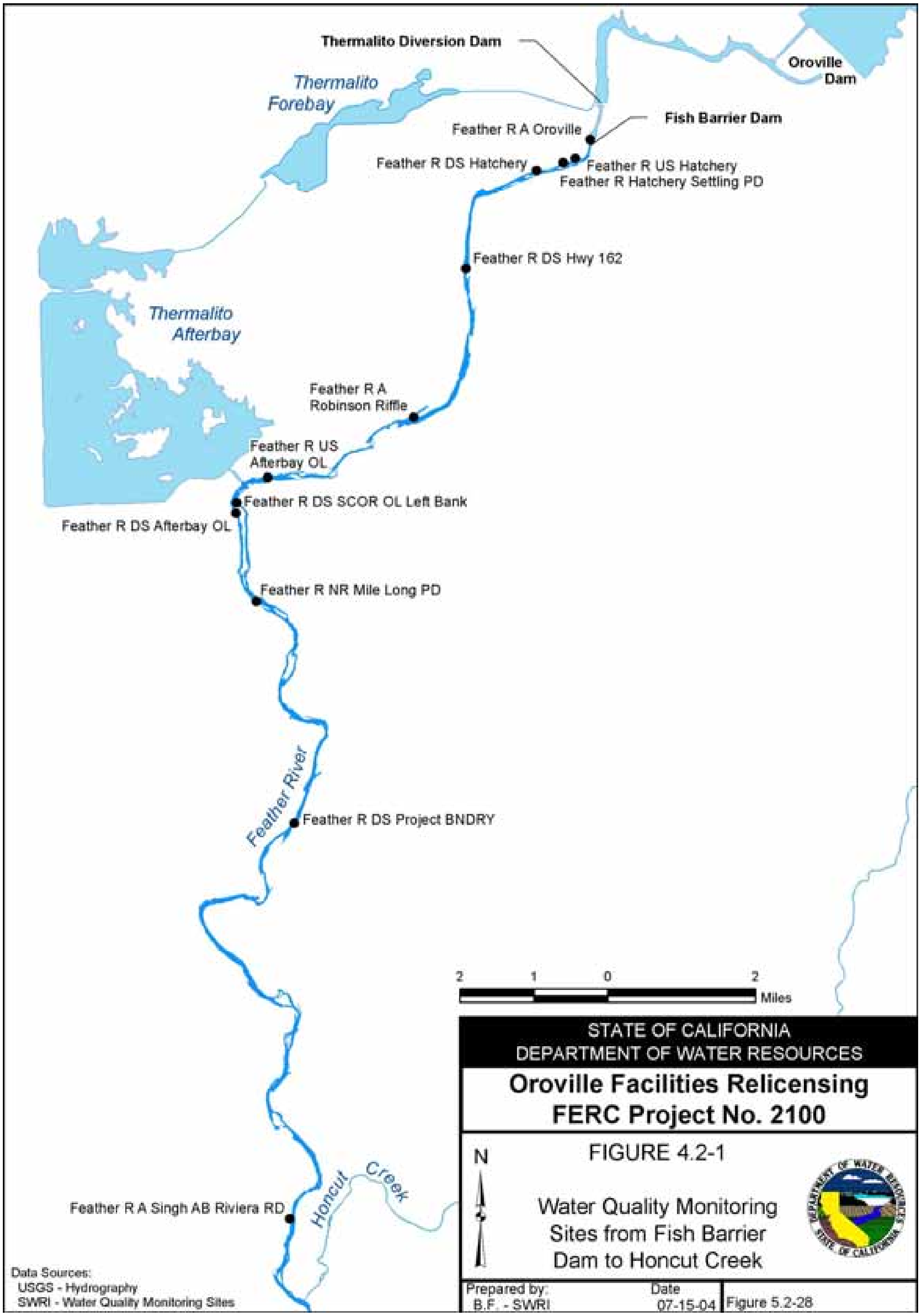


Figure 4.2-1. Water Quality Monitoring sites from Fish Barrier Dam to Honcut Creek.

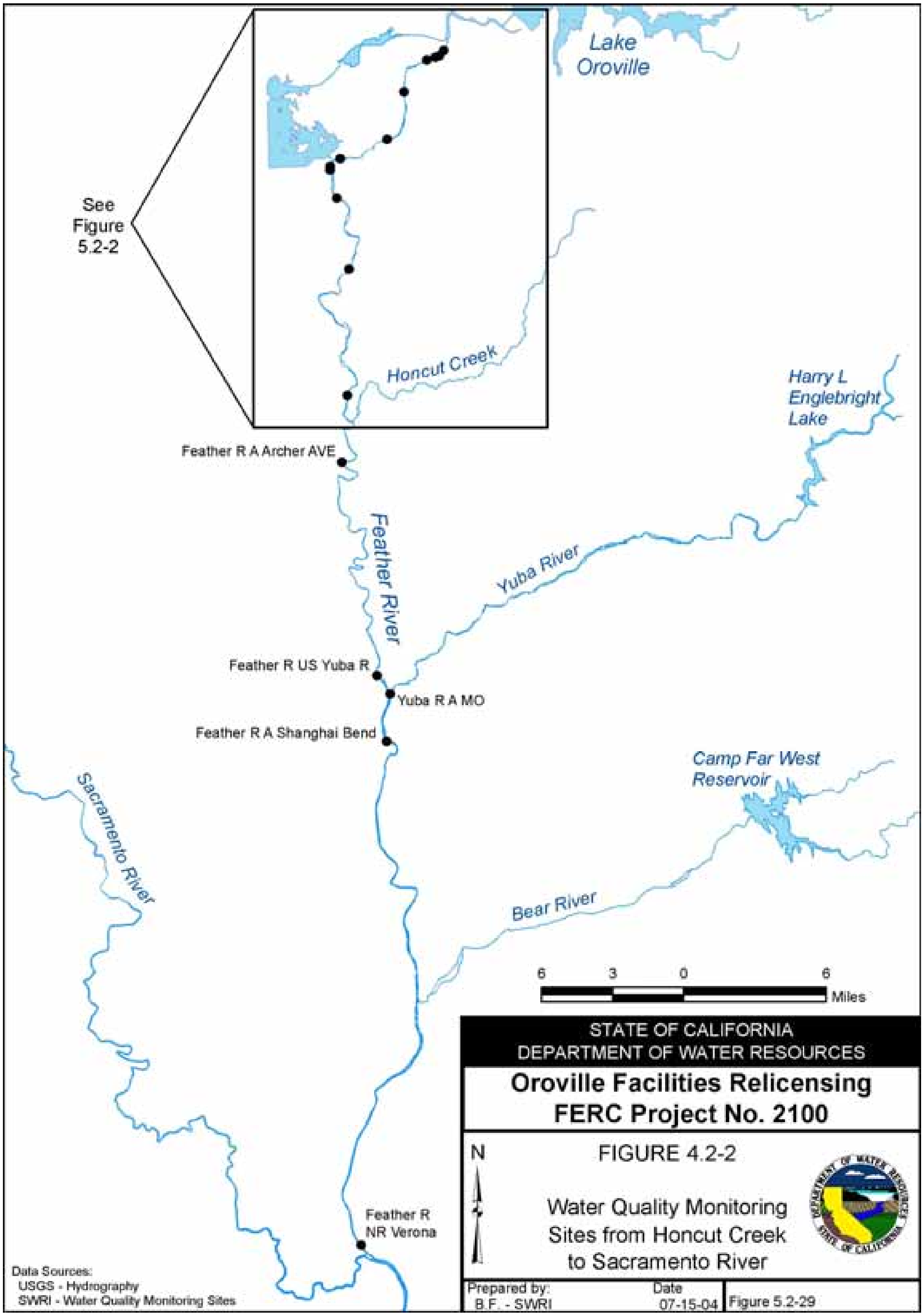


Figure 4.2-2. Water Quality Monitoring sites from Honcut Creek to Sacramento River.

4.2.7.2 Data Collection

The sampled pools were selected by searching for the deepest pools at locations that were near DWR's water quality and/or water temperature recorder locations on the Feather River. In cases where no distinct deep pools were located near water quality and/or water temperature recorders, habitat types were sampled that had similar characteristics to deep pools. A typical sampling event during the spring and early fall months began at Verona and continued upstream to the Fish Barrier Dam, a stretch of river that could be covered in one day during the spring and fall due to sufficient daylight into the early evening. During the time of year when days were shorter, DWR field crews usually ascended the river to the Near Mile Long Pond Pool or the Afterbay Outlet Pool. The remaining locations were sampled the following morning upstream from the last station monitored on the previous day. Sampling was completed using a YSI Model 550 Dissolved Oxygen/Water Temperature meter with a seven-meter cable. The probe was attached to an approximately 15-pound USGS Columbus Type Sounding Weight and lowered to a depth of 0.5 meters for an initial reading. The meter was calibrated at the first station sampled on each day by performing a Winkler titration for dissolved oxygen (mg/L). Once calibrated, the dissolved oxygen probe was brought up to approximately two inches below the water surface. DO concentration was recorded in a write-in-the-rain notebook. Subsequent readings were recorded in 0.5-meter increments until the bottom of the pool was reached (pers. comm., S. McReynolds 2003).

During sampling efforts in 2002, dissolved oxygen data were collected from April 30, 2002 through October 25, 2002. Figures 4.2-1 and 4.2-2 show the locations of DO concentration collection sites in 2002. Biweekly DO concentration data exist for the period from late April 2002 through October 2002 for the three most upstream pools sampled, all of which are located within the reach from the Thermalito Diversion Dam to the Thermalito Afterbay Outlet upstream from Mathews Riffle. All pool locations downstream from Highway 162 including the pool labeled "Upstream from HWY 162 Bridge Pool" contain data collected from August 2002 through October 25, 2002. Pools downstream from and including the pool labeled "Upstream from Yuba River Pool" were sampled on three dates in August 2002, and on two dates in both September and October 2002. Because all observed DO concentration levels met the minimum DO EPA threshold criteria, DO data were not included in 2003.

4.3 FISH HABITAT DEVELOPMENT

Fish habitat quality, quantity, and distribution are defined through the presence or absence of combinations of specific fish habitat components that are required by specific fish species. Fish habitat components characterized in the lower Feather River include mesohabitat type, substrate, water depth, instream cover complexity, water temperature and DO concentration. Individual fish utilize a range of habitat types with different levels of intensity and duration depending on life stage and activities including seasonal movements or migration, residence, foraging, spawning, nesting, initial rearing, juvenile rearing, etc. The importance of a fish habitat component is variable based on the type and intensity of use by the fish. For example, suitable spawning substrate is a requisite for defining spawning habitat for some species because spawning cannot occur without the appropriate substrate, while instream cover may be strongly preferred by rearing juveniles of some species, instream cover is not a required fish habitat component for juvenile rearing because rearing has been observed in locations without cover.

4.3.1 Fish Habitat Classification

Development of the fish habitat distribution by species was conducted in three steps using both qualitative and quantitative data. First, a profile of fish habitat requirements by species was developed from the study plan report for SP-F3.2 Task 2, which are presented in (DWR 2004d). The second step used GIS analysis of fish habitat component attributes to identify locations in the lower Feather River that met the required habitat characteristics for each fish species. The fish habitat was then evaluated against each fish species and life stage water temperature tolerance range to determine the proportion of time during each life stage period that the water temperatures were within the reported water temperature tolerance range of the fish. The three-step fish habitat classification process resulted in the identification of the location, extent, and proportion of relative suitability of fish habitat by species and life stage for the lower Feather River.

Potential fish habitat components listed in the study plan that were not included in the evaluation of fish habitat include flow inundation boundaries interpolated from SP-G2 hydrology transects, SP-T4 terrestrial vegetation classifications, water quality and turbidity data from SP-W1, macroinvertebrate community structure from SP-F1, and flow data from USGS gage stations. None of these potential data sets identified in the study plan were found to be either suitable for these analyses or were requisite components of reliably identifying fish habitat or its proportional relative suitability.

The summary of fish habitat characteristics for each fish species was organized and documented on a “fish habitat query sheet” shown in Figure 4.3-1. The fish habitat query sheet was used as the basis for the GIS habitat queries to identify areas in the lower Feather River with habitat attributes matching fish species habitat requirements. Each fish species included in the F3.2 Task 4 and 5 study plan were profiled to define and document the fish habitat requirements and preferences. Appendix B shows the fish habitat query sheets for each of the fish species and life stages analyzed. If the fish species was only seasonally present in the lower Feather River, the period of presence was defined to establish the analysis period for the evaluation of fish habitat distribution and proportion of relative habitat suitability.

F3.2 Habitat Query Form

Species: **<Pick One>** ____________

Lifestage: <Pick One> ____________

☐ Resident *or* Start Date: ________ Peak Start Date: ________
End Date: ________ Peak End Date: ________

Suitable Mesohabitat (If a class is not selected, it will be excluded):
☐ Backwater ☐ Boulder Run ☐ Glide ☐ Pool ☐ Riffle ☐ Run

Preferred Mesohabitat:
☐ Backwater ☐ Boulder Run ☐ Glide ☐ Pool ☐ Riffle ☐ Run

Suitable Minimum Depth: ________ ☐ feet *or* ☐ meters

Suitable Maximum Depth: ________ ☐ feet *or* ☐ meters

Suitable Substrate (If a class is not selected, it will be excluded):
☐ Bedrock ☐ Boulder ☐ Cobble ☐ Gravel ☐ Sand ☐ Silt ☐ Clay

Preferred Substrate:
☐ Bedrock ☐ Boulder ☐ Cobble ☐ Gravel ☐ Sand ☐ Silt ☐ Clay

Preferred Instream Cover: <Pick One> ________

Preferred Vegetation:
☐ Aquatic/Sumberged ☐ Open Water ☐ Riparian Forest/Woodland

Suitable Minimum Temperature: ________ ☐°F *or* ☐°C

Suitable Maximum Temperature: ________ ☐°F *or* ☐°C

Preferred/Optimal Minimum Temperature: ________ ☐°F *or* ☐°C

Preferred/Optimal Maximum Temperature: ________ ☐°F *or* ☐°C

Lethal Minimum Temperature: ________ ☐°F *or* ☐°C

Lethal Maximum Temperature: ________ ☐°F *or* ☐°C

Suitable Minimum Dissolved Oxygen (mg/l): ________

Figure 4.3-1 Fish Habitat Query Sheet

Suitable mesohabitat types were identified on the fish habitat query sheets for each fish species. Because individuals use a wide range of mesohabitat types for varying purposes and at different levels of intensity, only those mesohabitat types that were uncharacteristic for a fish species to be observed using were excluded from the potential fish habitat identification. For example, if a fish species' habitat requirements were pools or backwater mesohabitat types, it would be uncharacteristic to find the species utilizing riffle type mesohabitat for more than brief foraging or transit types of activities. It also should be noted that within a mesohabitat unit, there may be a broad range of conditions that could provide some suitable and usable area for a individuals that would ordinarily not characteristically be present within the mesohabitat unit type. For example, it is possible for velocity refuges to be present in riffle mesohabitat units allowing species with low velocity preferences to utilize the riffle. In these cases, the mesohabitat unit would be classified as the lowest proportional relative habitat suitability, but acknowledge that some fish habitat utilization for that species may occur.

Suitable water depth range requirements for each fish species also were identified on the fish habitat query sheets. Species that reportedly tend to use mid-channel type habitat typically had minimum water depth requirements and species requiring shallow water habitat during the juvenile life stages typically had maximum water depth requirements. The water depths for each mesohabitat unit were the estimated average water depth for the unit. In reality, the range of depths within a mesohabitat unit is a continuum, ranging from a depth greater than the average depth of the unit to zero depth at the margins of the unit. Even when the minimum or maximum water depth criteria were not met for a specific species, it is likely that some suitable areas, either a deep hole or a shallow margin, would provide some depths within a habitat unit that may not otherwise be classified as suitable. In cases were the minimum or maximum water depth criteria were not met, the habitat unit was classified as the lowest proportional relative habitat suitability, but acknowledged that some amount of fish habitat utilization could occur.

Suitable substrate requirements for each fish species also were identified. The SP-G2 classification of substrates did not specify dominant substrate type or specific substrate component proportions, so the use of substrate type as part of the fish habitat classification only excluded those substrate types that were uncharacteristic of the fish habitat requirements. Substrate types assigned to an entire mesohabitat unit generalize a range of substrate conditions and do not definitively determine that none of a required substrate type could be present. Because substrate characterization data were general, it was acknowledged that some fish habitat use could occur within a unit in which reported substrate is unsuitable. However, in mesohabitat units in which substrate was reported as unsuitable, it is likely that habitat utilization would occur at the lowest level of proportion of relative use in comparison with habitat units with the desirable habitat components explicitly present.

Qualitative exclusionary criteria was used in the GIS query structure of fish habitat components for mesohabitat type, water depth, and substrate type to qualify potential fish habitat as “lowest potential fish habitat suitability” or “potentially suitable fish habitat” by fish species. It should be noted, however, that “lowest potential fish habitat suitability” does not indicate that the fish species would never utilize the habitat to any degree, but does indicate that the habitat typically would only be used for short duration activities, such as transit to another mesohabitat unit, or as a foraging area. Alternatively, “lowest potential fish habitat suitability” acknowledges that the diversity of habitat conditions within a habitat unit allows some portion of the area within the unit to meet the fish habitat requirements.

The third step in the fish habitat distribution development process is the quantitative comparison of the water temperatures for each habitat unit to the water temperature tolerance range of the fish species in the life stage period being evaluated to determine the proportion of relative fish habitat suitability. Those habitat units meeting the fish species habitat component criteria and that have water temperatures within the water temperature tolerance ranges for the entire period for analysis were assigned the highest proportion of relative habitat suitability. Those habitat units meeting the fish species habitat component criteria and with water temperatures that were outside the water temperature tolerance ranges for some time during the period of analysis were assigned lower proportions of relative habitat suitability.

4.3.2 Data Collection

No data were collected in this sub-task, but the analysis methods described in this section utilize all other fish habitat component data collected. The results produced in this sub-task are habitat units of the river defined by GIS polygons that are assigned a proportion of relative habitat suitability for each of the fish species analyzed.

4.4 FISH DISTRIBUTION VS. FISH HABITAT COMPARISON

Both fish species distribution and fish habitat distribution are generalized representations of dynamic conditions, are based on very different data sources and assumptions, and have different relative strengths and weaknesses in their spatial and temporal resolution and accuracy of characterization of fisheries resources. Although both fish species distributions and habitat distributions have their limitations, the direct comparison of these fisheries resource definitions could be utilized to determine information limiting the accurate characterization of these resources and to determine the relative degree of confidence with which the results of these analyses should be used in future resource management decisions and potential Resource Action evaluations.

4.4.1 Fish Distribution vs. Fish Habitat Comparison Classification

The GIS was used to compare fish distribution to fish habitat for each fish species evaluated. In locations were the definitions of the fish distribution and fish habitat concurred, the amount of area and proportion of area that concurred in each lower Feather River reach were calculated. When the fish distribution and fish habitat definitions conflicted, the amount of area and proportion of area that conflicted in each lower Feather River reach were reported by type of disagreement.

4.4.2 Data Collection

No data were collected in this sub-task, but the analysis methods described in this section utilized both the fish distribution data collected and the suitable fish habitat units delineated in the GIS. The results produced in this sub-task were tables reporting the proportion of area in each lower Feather River reach by species that concurred for fish species and habitat distribution definitions. Similarly, the amount and proportion of disagreement by type also was reported (see Section 5.4).

5.0 RESULTS

5.1 FISH DISTRIBUTION

5.1.1 Data Summary

Fish distribution information was developed utilizing three distinctly different collection methods including snorkel surveys, rotary screw trapping, and seine surveys. Data sets were combined to provide the most comprehensive set of the temporal, spatial, and relative abundance information available to characterize fish species distribution in the lower Feather River.

5.1.2 Data Limitations

The relative abundance of fishes in the lower Feather River was determined by direct observation in locations where surveys occurred. However, the full extent of the distribution of fishes also was based on the best professional judgment of DWR biologists. Fish species distribution data represented the known or probable presence of fish species within the lower Feather River. An additional limitation of the data is that some data represent single sampling events. Because fish distribution can be seasonal and dynamic based on habitat conditions (i.e., changes in flow or water temperature) distribution maps presented in this report are generalized representations of actual fish distributions.

5.1.2.1 Snorkel Survey Data Limitations

Snorkel surveys were applicable to the physical site conditions of Feather River because the number of snorkelers used could be adjusted, depending upon river conditions, in order to ensure adequate coverage of each segment of river. However, snorkeling typically is not effective when water quality conditions are turbid or flows are too high to be considered safe (Dolloff and Reeves 1990). In some cases snorkeling was performed in sub-optimal conditions, which likely limited the efficiency of the surveys. Snorkeling does not provide as accurate a counting mechanism as other devices, such as RSTs, because of individual sampling bias, which typically is greater on larger rivers such as the Feather River (Dolloff and Reeves 1990). Unlike RSTs, snorkel surveys do not allow for continuous sampling. Additionally, because fish typically are not captured, mark-recapture tests are not generally conducted in order to calibrate observational data. For these reasons, snorkel surveys that have previously been conducted on the Feather River have focused on obtaining data regarding fish distribution rather than focusing on estimating fish population sizes. Additionally, a snorkel survey does not obtain fish metrics such as fish length and sex.

Snorkel survey data are effective for defining fish distribution and relative abundance through a series of observations at different levels of survey scale and observation intensity. Although snorkeling can provide important data, quantitative application of snorkel data may be limited due to special considerations when observation conditions are less than ideal. For example, in waters with dark substrate, benthic fishes may be difficult to observe when snorkeling. Snorkelers may fail to detect or incorrectly identify target organisms, count them more than once, or inaccurately estimate size. Additionally, some species and sizes of fish are more difficult to see than others, especially species that remain near the substrate or concealed by cover. Differences in fish behavior during times of the day or year also may influence observability.

5.1.2.2 RST data limitations

RST are continuous sampling devices that provide reliable species identification and temporal distribution information. RST data represents fish species composition and enumeration for a single geographic point at the trap location. Therefore, the geographic resolution of the definition of fish species distribution is limited. RST's require adequate water velocities to increase the rotation speed of the capture drum in order to obtain a high capture efficiency (Demko et al. 1998). Debris capture increases with higher water velocities, however (Snider 1992). RST efficiency has been reported to be consistently low in large rivers (Snider and Titus 2000), potentially because RST's sample only a portion of the cross-sectional area of the river (Kennen et al. 1994). Additionally, RST's require depths greater than 6 ft, velocities greater than 2 ft/s, sufficient anchoring points, and limited public access (DWR 2002b). Large individuals could potentially avoid traps creating a bias in the size and species of fish captured during some times of year while smaller individuals, particularly fry, can become impinged against the cleaning drum, which could lead to lower efficiency or injury to downstream migrating individuals (Thedinga et al. 1994). Extreme flow conditions (high and low) also affect trap efficiency (Kennen et al. 1994).

5.1.2.3 Seining data limitation

Seining provides the ability to obtain fish species distribution from repeated sampling events at observation intervals for a number of geographic locations. Beach seine capture efficiency has been found to vary with the position of each species within the water column and also varies with fish behavior (Hayes et al. 1996). Capture efficiency is related to the substrate structure of the area being sampled (i.e., structures that cause the seine to snag or roll will reduce efficiency) (Hayes et al. 1996). Applicability of this fish sampling method is limited to shallow water with a fairly uniform bottom and low water velocities. Consequently, fish seine sampling typically does not capture fish in deep-watered, rough-bottomed, or swift moving habitats. Additionally, some fish could avoid the nets lowering capture efficiency (DWR 2002a).

5.1.3 Fish Species Geographic Distribution and Relative Abundance

Fish spatial distribution and relative abundance were mapped in the lower Feather River. Spatial analysis of fish distribution and environmental data reveals areas where the spatial association between abiotic habitat features and fish species appears. The mapping of such areas is a spatial measure that could be used in species population management.

Chinook salmon and Sacramento sucker were the most common species captured during DWR surveys comprising over 85 percent of the catch. No other species exceeded ten percent of the total. In general, non-native species were most prevalent in the reach of the Feather River extending from the Thermalito Afterbay Outlet to Boyd's pump, while natives resided throughout the study area. Of the 35 species observed in the Feather River by Painter (Painter et al. 1977), DWR collected 26 species during recent survey efforts (DWR 2002a).

Between the Thermalito Afterbay Outlet and the confluence with the Sacramento River, American shad, several species of centrarchids, hitch, striped bass, and tule perch were frequently observed whereas green and white sturgeon were infrequently observed. Between the Fish Barrier Dam and the confluence with the Sacramento River, hardhead and Sacramento pikeminnow, Pacific lamprey, and Sacramento sucker were frequently observed whereas river lamprey were infrequently observed (Table 5.1-1).

Table 5.1-1. Potential distribution and relative abundance by fish taxa by reach in the Feather River.

Fish taxa	Frequently observed	Infrequently observed	Not observed
American Shad	Thermalito Afterbay Outlet to the confluence with the Sacramento River	Steep Riffle to Thermalito Afterbay Outlet	Thermalito Diversion Dam to Steep Riffle
Centrarchids	Thermalito Afterbay Outlet to the confluence with the Sacramento River	Thermalito Diversion Dam to the Fish Barrier Dam and from Steep Riffle to Thermalito Afterbay Outlet	Fish Barrier Dam to Steep Riffle
Green Sturgeon		Thermalito Afterbay Outlet to the confluence with the Sacramento River	Thermalito Diversion Dam to Thermalito Afterbay Outlet
Hardhead and Sacramento Pikeminnow	Fish Barrier Dam to confluence with the Sacramento River	Thermalito Diversion Dam to the Fish Barrier Dam	
Hitch	Thermalito Afterbay Outlet to the confluence with the Sacramento River		Thermalito Diversion Dam to Thermalito Afterbay Outlet
Pacific Lamprey	Fish Barrier Dam to confluence with the Sacramento River		Thermalito Diversion Dam to the Fish Barrier Dam
River Lamprey		Fish Barrier Dam to confluence with the Sacramento River	Thermalito Diversion Dam to the Fish Barrier Dam
Sacramento Splittail		Honcut Creek to the confluence with the Sacramento River	Thermalito Diversion Dam to Honcut Creek
Sacramento Sucker	Fish Barrier Dam to confluence with the Sacramento River	Thermalito Diversion Dam to the Fish Barrier Dam	

Fish taxa	Frequently observed	Infrequently observed	Not observed
Striped Bass	Thermalito Afterbay Outlet to the confluence with the Sacramento River	Steep Riffle to Thermalito Afterbay Outlet	Thermalito Diversion Dam to Steep Riffle
Tule Perch	Thermalito Afterbay Outlet to the confluence with the Sacramento River	Fish Barrier Dam to Thermalito Afterbay Outlet	Thermalito Diversion Dam to the Fish Barrier Dam
White Sturgeon		Thermalito Afterbay Outlet to the confluence with the Sacramento River	Thermalito Diversion Dam to Thermalito Afterbay Outlet

"Frequently Observed" or "Infrequently Observed" is relative only within a specific species. Relative abundance does not apply across species (e.g., "Frequently Observed" for hitch does not mean that the number of hitch is of the same order of magnitude as "Frequently Observed" Sacramento Splittail).

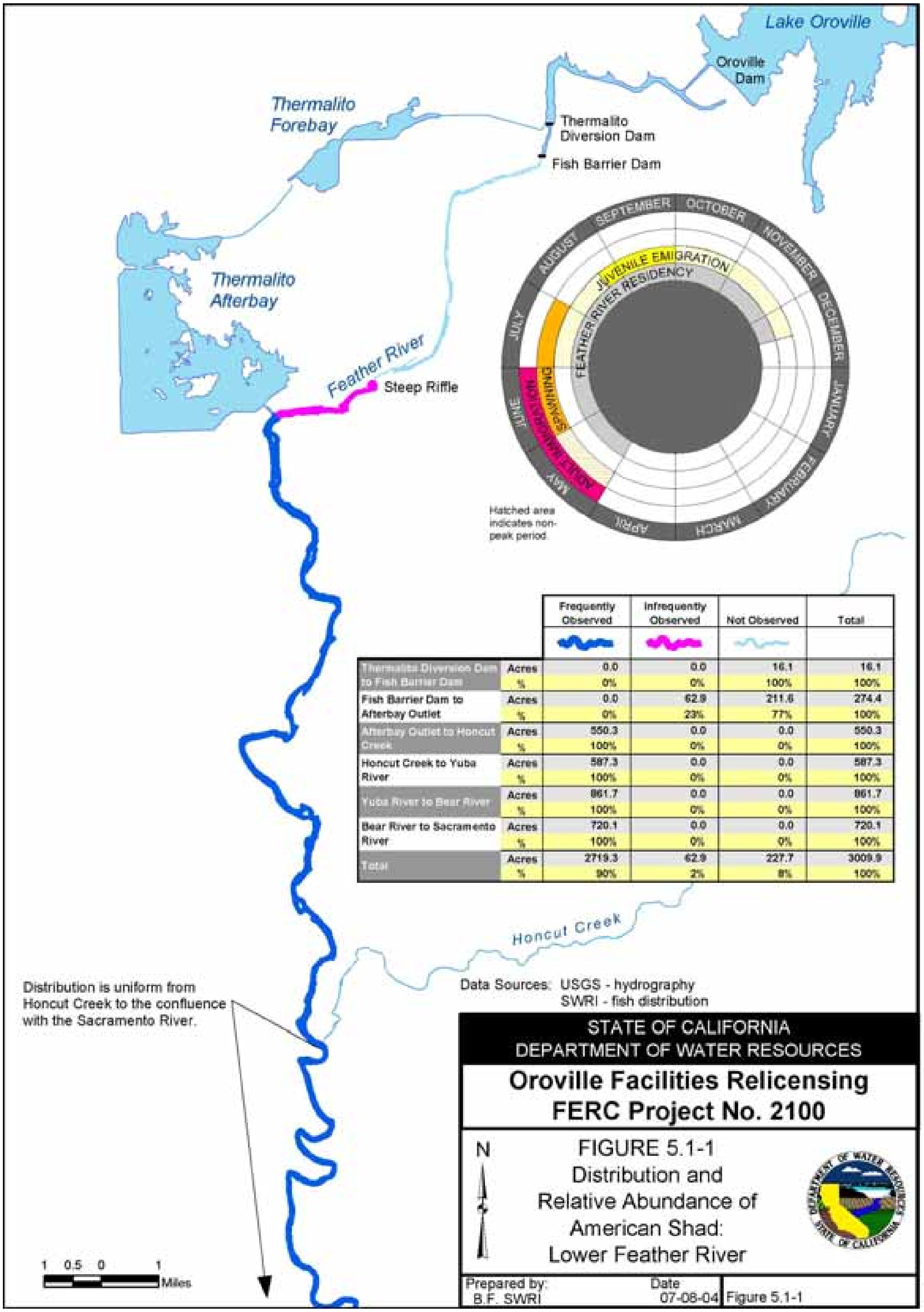
5.1.3.1 American Shad

American shad were not observed from the Thermalito Diversion Dam to Steep Riffle, which comprised an area of 228 acres or 8 percent of the lower Feather River. The species was infrequently observed from the Steep Riffle to the Thermalito Afterbay Outlet, which comprised an area of 63 acres or 2 percent of the lower Feather River. The area from Steep Riffle to the Thermalito Afterbay outlet comprises approximately 20 percent of the area within the reach from the Fish Barrier Dam to the Thermalito Afterbay Outlet (LFC). American shad were frequently observed from the Thermalito Afterbay Outlet to the confluence with the Sacramento River, which comprised an area of 2,719 acres or 90 percent of the lower Feather River (Figures 5.1-1 and 5.1-2).

5.1.3.2 Centrarchids

Because several centrarchid species were identified in the lower Feather River, because those species are reported to have similar habitat preferences, and because they often were identified in the same mesohabitat unit or in similar habitats, results of species distribution surveys included all identified centrarchids together.

Centrarchids were infrequently observed from the Thermalito Diversion Dam to the Fish Barrier Dam (i.e., Fish Barrier Pool), which comprised an area of 16 acres that accounted for 0.6 percent of the lower Feather River, and were not observed from the Fish Barrier Dam to Steep Riffle, which comprised an area of 212 acres that accounted for 7 percent of the lower Feather River. Centrarchids were infrequently observed from Steep Riffle to the Thermalito Afterbay Outlet, which comprised an area of 63 acres and accounted for 2.4 percent of the lower Feather River. Centrarchid fishes were frequently observed from the Thermalito Afterbay Outlet to the confluence with the Sacramento River, which comprised an area of 2,719 acres that accounted for 90 percent of the lower Feather River (Figures 5.1-3 and 5.1-4).



		Frequently Observed	Infrequently Observed	Not Observed	Total
Thermalito Diversion Dam to Fish Barrier Dam	Acres	0.0	0.0	16.1	16.1
	%	0%	0%	100%	100%
Fish Barrier Dam to Afterbay Outlet	Acres	0.0	62.9	211.6	274.4
	%	0%	23%	77%	100%
Afterbay Outlet to Honcut Creek	Acres	550.3	0.0	0.0	550.3
	%	100%	0%	0%	100%
Honcut Creek to Yuba River	Acres	587.3	0.0	0.0	587.3
	%	100%	0%	0%	100%
Yuba River to Bear River	Acres	861.7	0.0	0.0	861.7
	%	100%	0%	0%	100%
Bear River to Sacramento River	Acres	720.1	0.0	0.0	720.1
	%	100%	0%	0%	100%
Total	Acres	2719.3	62.9	227.7	3009.9
	%	90%	2%	8%	100%

Figure 5.1-1. American shad distribution and relative abundance in the Feather River from the Fish Barrier Pool to the confluence with the Sacramento River.

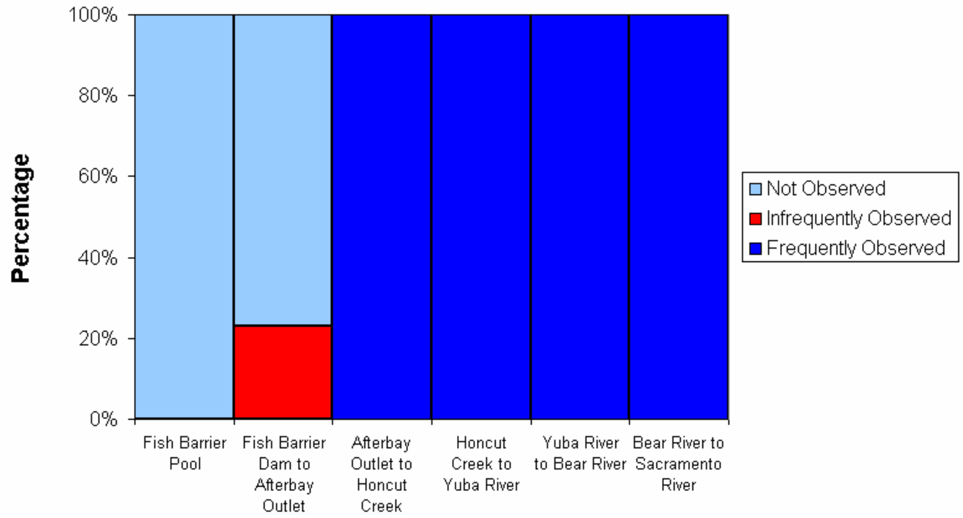
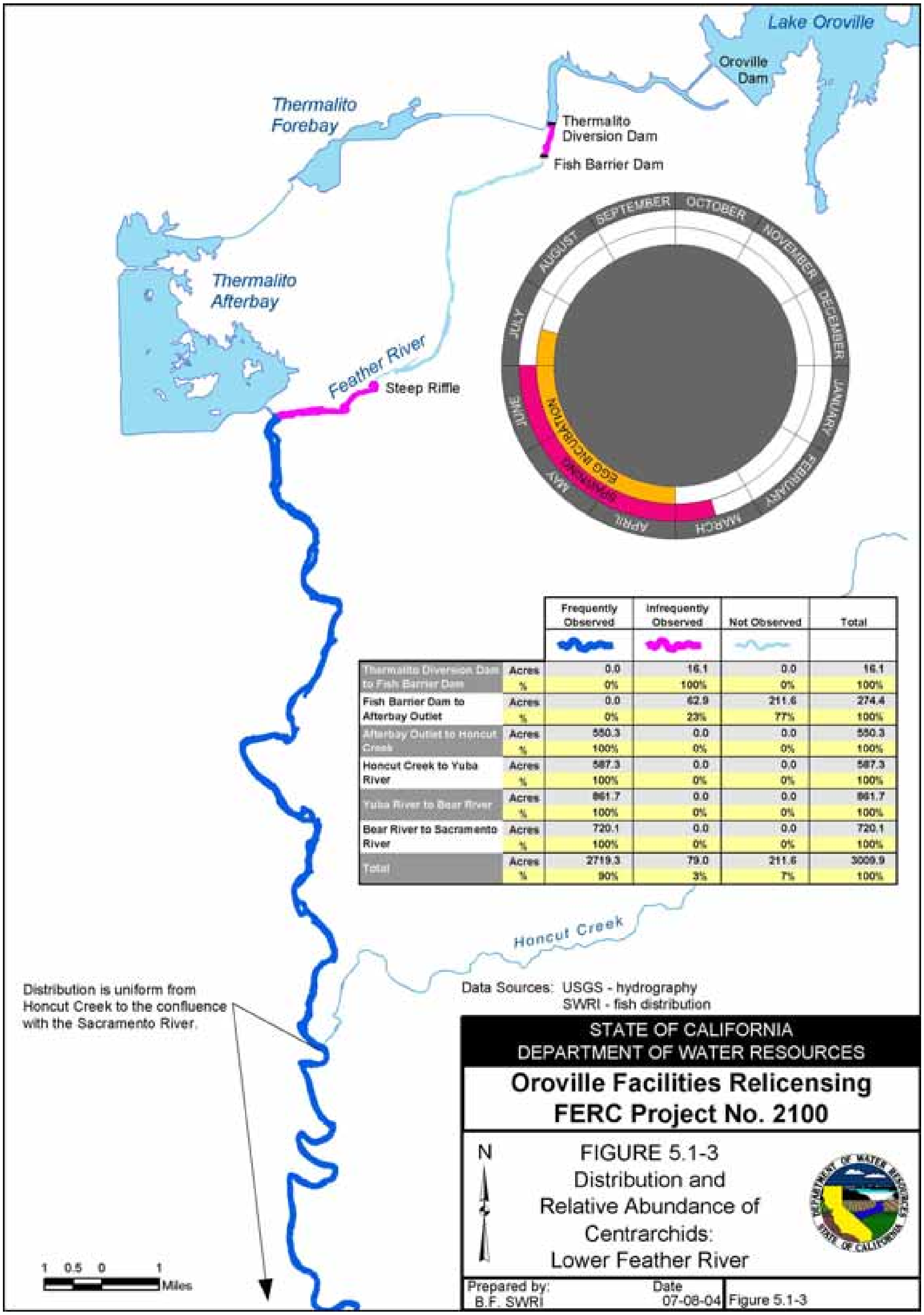


Figure 5.1-2. Proportions of relative abundance of American shad by reach in the Feather River from the Fish Barrier Pool to the confluence with the Sacramento River.



		Frequently Observed	Infrequently Observed	Not Observed	Total
Thermalito Diversion Dam to Fish Barrier Dam	Acres	0.0	16.1	0.0	16.1
	%	0%	100%	0%	100%
Fish Barrier Dam to Afterbay Outlet	Acres	0.0	62.9	211.6	274.4
	%	0%	23%	77%	100%
Afterbay Outlet to Honcut Creek	Acres	550.3	0.0	0.0	550.3
	%	100%	0%	0%	100%
Honcut Creek to Yuba River	Acres	587.3	0.0	0.0	587.3
	%	100%	0%	0%	100%
Yuba River to Bear River	Acres	861.7	0.0	0.0	861.7
	%	100%	0%	0%	100%
Bear River to Sacramento River	Acres	720.1	0.0	0.0	720.1
	%	100%	0%	0%	100%
Total	Acres	2719.3	79.0	211.6	3009.9
	%	90%	3%	7%	100%

Figure 5.1-3. Centrarchids distribution and relative abundance in the Feather River from the Fish Barrier Pool to the confluence with the Sacramento River.

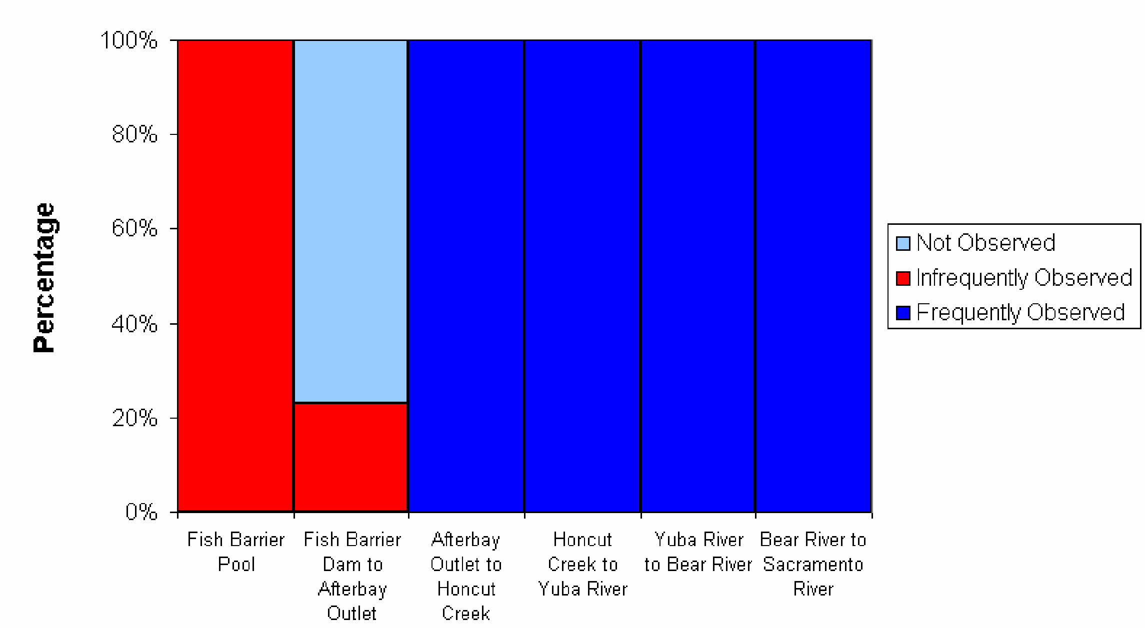
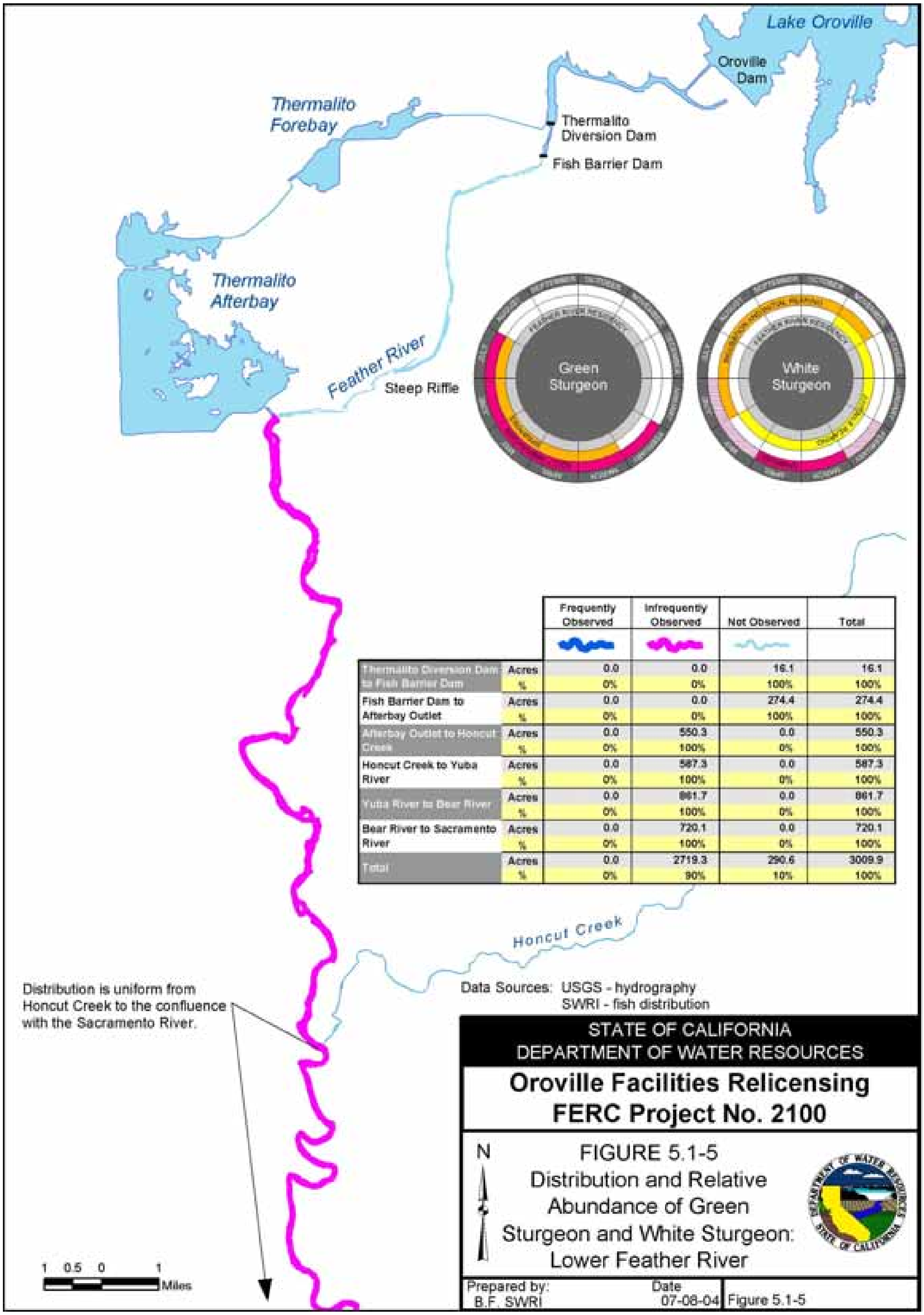


Figure 5.1-4. Proportions of relative abundance of Centrarchids by reach in the Feather River from the Fish Barrier Pool to the confluence with the Sacramento River.

5.1.3.3 Green Sturgeon and White Sturgeon

Green sturgeon and white sturgeon were not observed from the Diversion Dam to the Thermalito Afterbay Outlet, which comprised an area of 291 acres that accounted for 10 percent of the lower Feather River, but were infrequently observed from the Thermalito Afterbay Outlet to the confluence with the Sacramento River, which comprised 2,719 acres that accounted for 90 percent of the lower Feather River (Figures 5.1-5 and 5.1-6).



		Frequently Observed	Infrequently Observed	Not Observed	Total
Thermalito Diversion Dam to Fish Barrier Dam	Acres	0.0	0.0	16.1	16.1
	%	0%	0%	100%	100%
Fish Barrier Dam to Afterbay Outlet	Acres	0.0	0.0	274.4	274.4
	%	0%	0%	100%	100%
Afterbay Outlet to Honcut Creek	Acres	0.0	550.3	0.0	550.3
	%	0%	100%	0%	100%
Honcut Creek to Yuba River	Acres	0.0	587.3	0.0	587.3
	%	0%	100%	0%	100%
Yuba River to Bear River	Acres	0.0	861.7	0.0	861.7
	%	0%	100%	0%	100%
Bear River to Sacramento River	Acres	0.0	720.1	0.0	720.1
	%	0%	100%	0%	100%
Total	Acres	0.0	2719.3	290.6	3009.9
	%	0%	90%	10%	100%

Figure 5.1-5. Green Sturgeon and White Sturgeon distribution and relative abundance in the Feather River from the Fish Barrier Pool to the confluence with the Sacramento River.

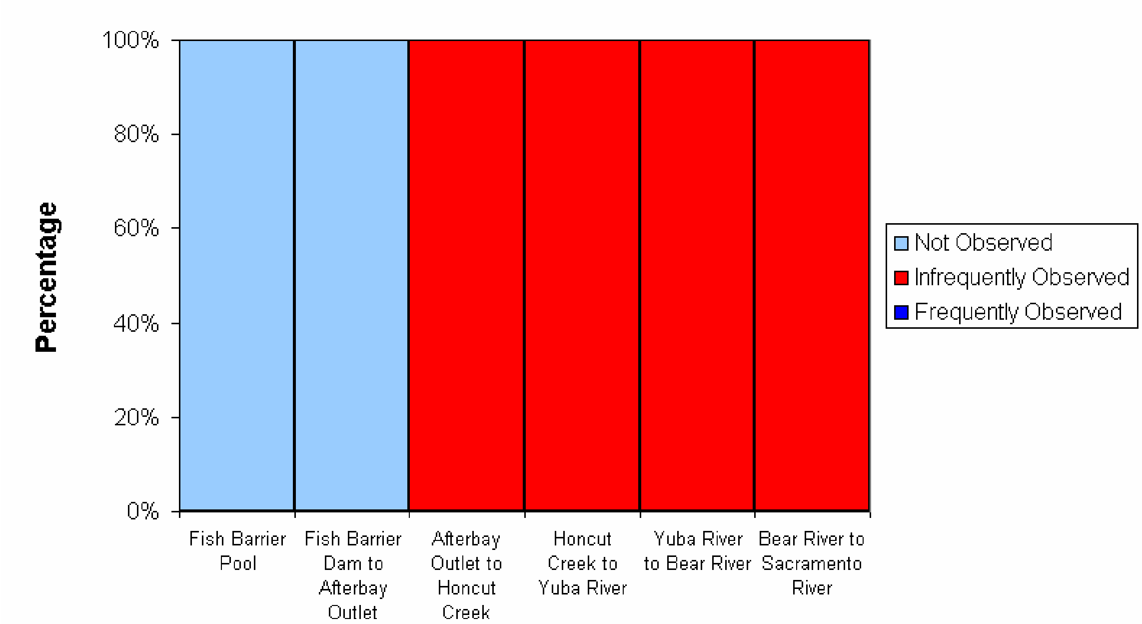
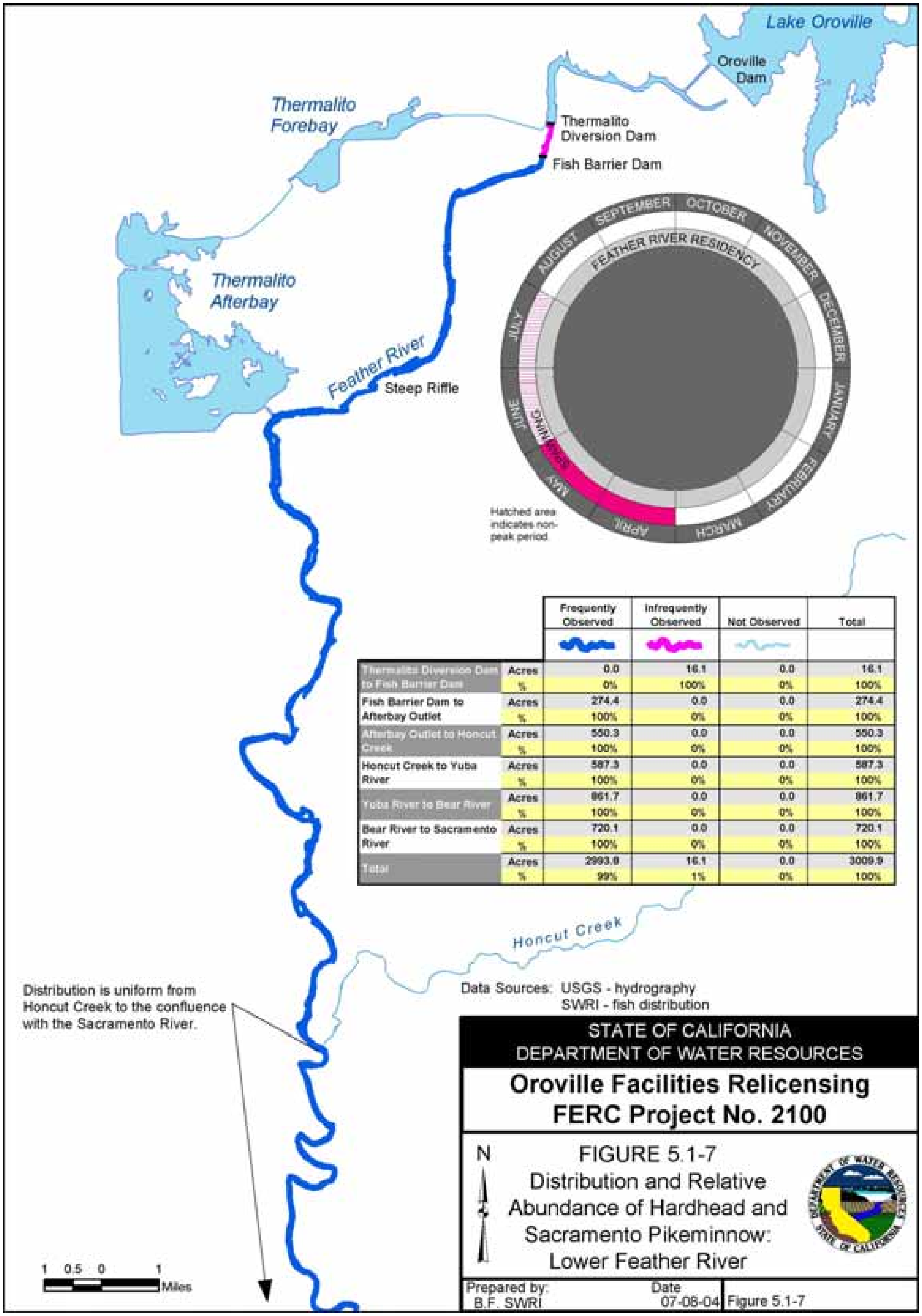


Figure 5.1-6. Proportions of relative abundance of Green Sturgeon and White Sturgeon by reach in the Feather River from the Fish Barrier Pool to the confluence with the Sacramento River.

5.1.3.4 Hardhead and Sacramento Pikeminnow

Hardhead and Sacramento pikeminnow were infrequently observed from the Thermalito Diversion Dam to the Fish Barrier Dam (i.e., Fish Barrier Pool), which comprised an area of 16 acres that accounted for 1 percent of the lower Feather River. Both species frequently have been observed from the Fish Barrier Dam to the confluence with the Sacramento River, which comprised an area of 2,994 acres that accounted for 99 percent of the lower Feather River (Figures 5.1-7 and 5.1-8).



		Frequently Observed	Infrequently Observed	Not Observed	Total
Thermalito Diversion Dam to Fish Barrier Dam	Acres	0.0	16.1	0.0	16.1
	%	0%	100%	0%	100%
Fish Barrier Dam to Afterbay Outlet	Acres	274.4	0.0	0.0	274.4
	%	100%	0%	0%	100%
Afterbay Outlet to Honcut Creek	Acres	550.3	0.0	0.0	550.3
	%	100%	0%	0%	100%
Honcut Creek to Yuba River	Acres	587.3	0.0	0.0	587.3
	%	100%	0%	0%	100%
Yuba River to Bear River	Acres	861.7	0.0	0.0	861.7
	%	100%	0%	0%	100%
Bear River to Sacramento River	Acres	720.1	0.0	0.0	720.1
	%	100%	0%	0%	100%
Total	Acres	2993.8	16.1	0.0	3009.9
	%	99%	1%	0%	100%

Figure 5.1-7. Hardhead and Sacramento Pikeminnow distribution and relative abundance in the Feather River from the Fish Barrier Pool to the confluence with the Sacramento River.

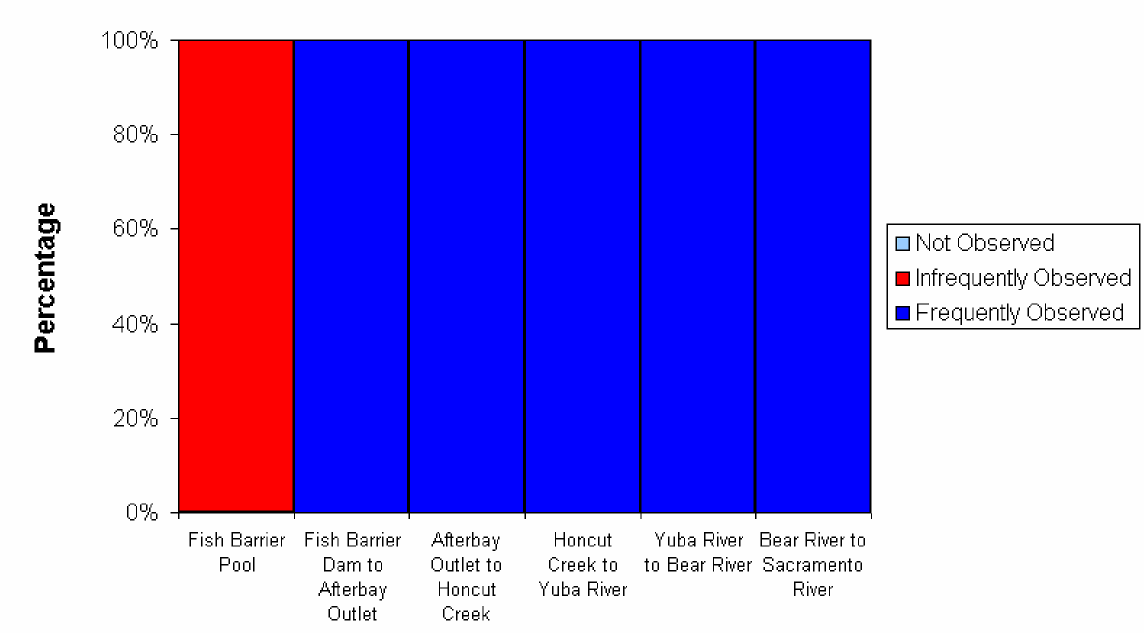
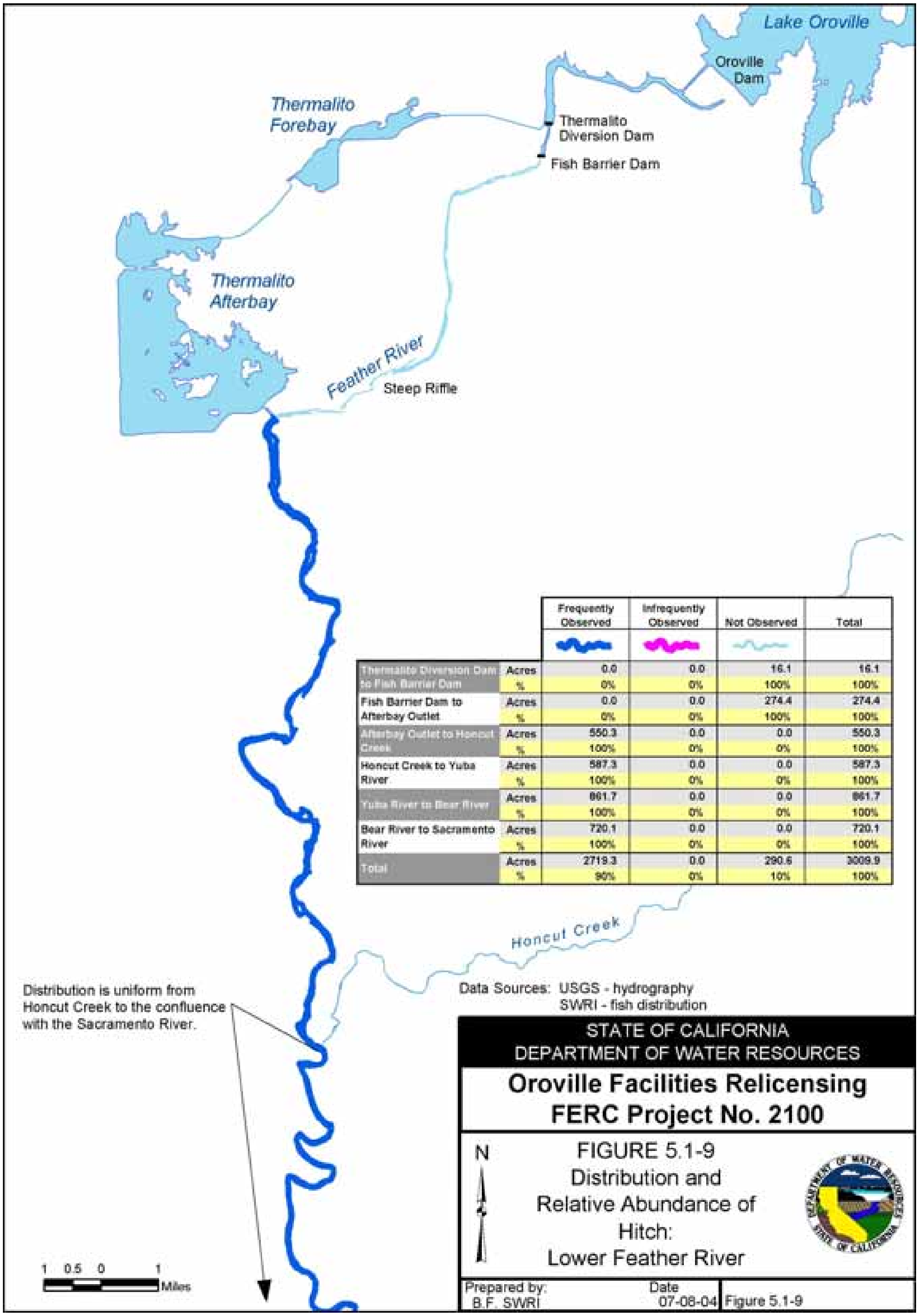


Figure 5.1-8. Proportions of relative abundance of Hardhead and Sacramento Pikeminnow by reach in the Feather River from the Fish Barrier Pool to the confluence with the Sacramento River.

5.1.3.5 Hitch

Hitch have not been observed from the Thermalito Diversion Dam to the Thermalito Afterbay Outlet, an area that comprised 291 acres that accounted for 10 percent of the lower Feather River. However, hitch were frequently observed from the Thermalito Afterbay Outlet to the confluence with the Sacramento River, which comprised an area of 2,719 acres that accounted 90 percent of the lower Feather River (Figures 5.1-9 and 5.1-10).



		Frequently Observed	Infrequently Observed	Not Observed	Total
Thermalito Diversion Dam to Fish Barrier Dam	Acres	0.0	0.0	16.1	16.1
	%	0%	0%	100%	100%
Fish Barrier Dam to Afterbay Outlet	Acres	0.0	0.0	274.4	274.4
	%	0%	0%	100%	100%
Afterbay Outlet to Honcut Creek	Acres	550.3	0.0	0.0	550.3
	%	100%	0%	0%	100%
Honcut Creek to Yuba River	Acres	587.3	0.0	0.0	587.3
	%	100%	0%	0%	100%
Yuba River to Bear River	Acres	861.7	0.0	0.0	861.7
	%	100%	0%	0%	100%
Bear River to Sacramento River	Acres	720.1	0.0	0.0	720.1
	%	100%	0%	0%	100%
Total	Acres	2719.3	0.0	290.6	3009.9
	%	90%	0%	10%	100%

Figure 5.1-9. Hitch distribution and relative abundance in the Feather River from the Fish Barrier Pool to the confluence with the Sacramento River.

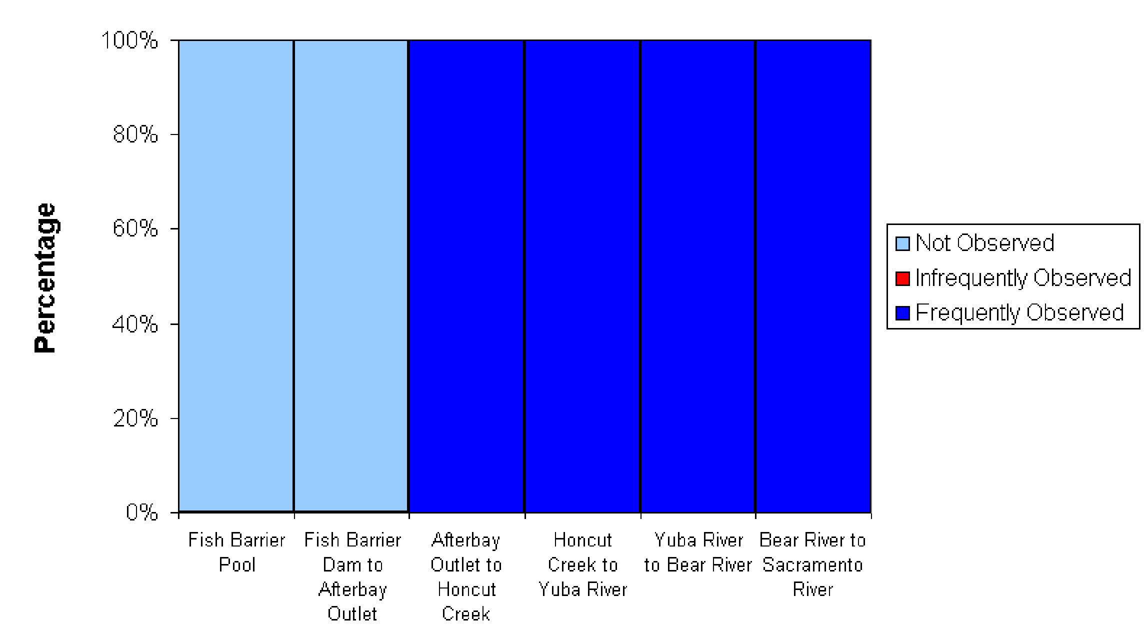
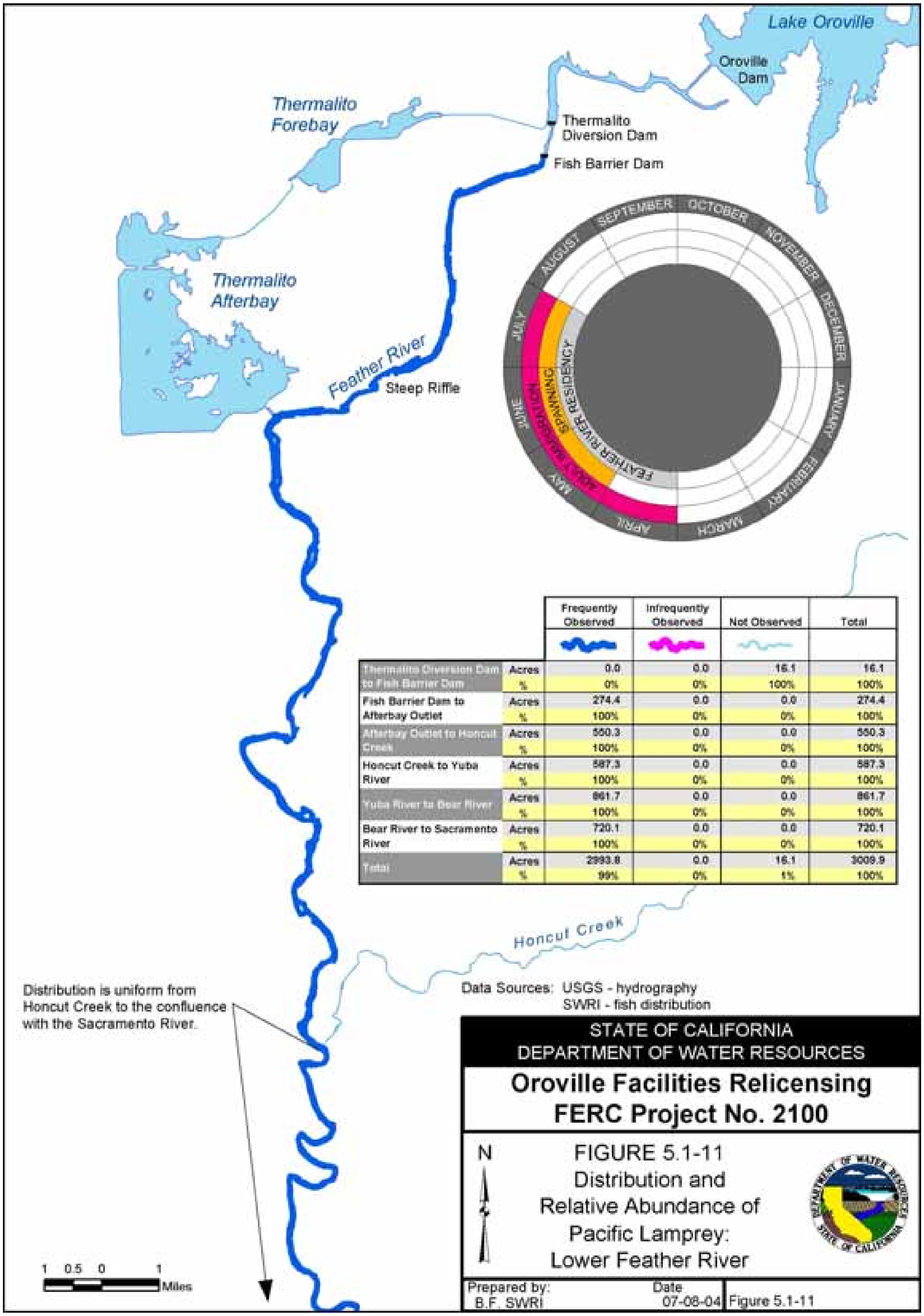


Figure 5.1-10. Proportions of relative abundance of Hitch by reach in the Feather River from the Fish Barrier Pool to the confluence with the Sacramento River.

5.1.3.6 Pacific Lamprey

Pacific lamprey have not been observed from the Thermalito Diversion Dam to the Fish Barrier Dam (i.e., the Fish Barrier Pool), which comprised an area of 16 acres that accounted for 1 percent of the lower Feather River. Hitch were frequently observed from the Fish Barrier Dam to the confluence with the Sacramento River, which comprised an area of 2,994 acres that accounted for 99 percent of the lower Feather River (Figures 5.1-11 and 5.1-12).



		Frequently Observed	Infrequently Observed	Not Observed	Total
Thermalito Diversion Dam to Fish Barrier Dam	Acres	0.0	0.0	16.1	16.1
	%	0%	0%	100%	100%
Fish Barrier Dam to Afterbay Outlet	Acres	274.4	0.0	0.0	274.4
	%	100%	0%	0%	100%
Afterbay Outlet to Honcut Creek	Acres	550.3	0.0	0.0	550.3
	%	100%	0%	0%	100%
Honcut Creek to Yuba River	Acres	587.3	0.0	0.0	587.3
	%	100%	0%	0%	100%
Yuba River to Bear River	Acres	861.7	0.0	0.0	861.7
	%	100%	0%	0%	100%
Bear River to Sacramento River	Acres	720.1	0.0	0.0	720.1
	%	100%	0%	0%	100%
Total	Acres	2993.8	0.0	16.1	3009.9
	%	99%	0%	1%	100%

Figure 5.1-11. Pacific lamprey distribution and relative abundance in the Feather River from the Fish Barrier Pool to the confluence with the Sacramento River.

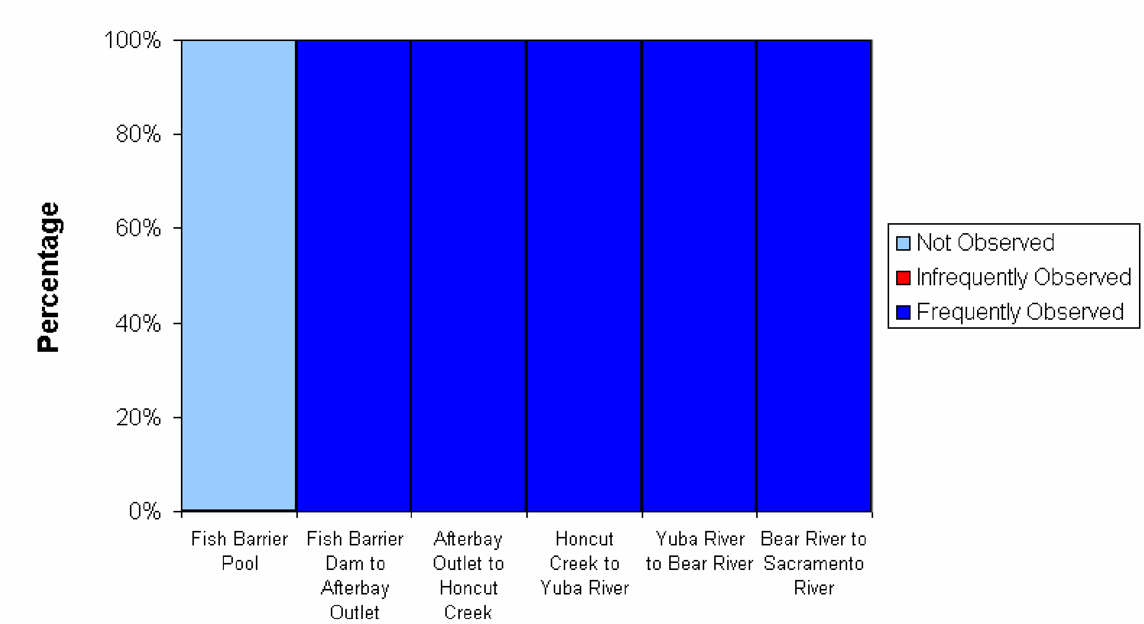


Figure 5.1-12. Proportions of relative abundance of Pacific Lamprey by reach in the Feather River from the Fish Barrier Pool to the confluence with the Sacramento River.

5.1.3.7 River Lamprey

River lamprey have not been observed from the Thermalito Diversion Dam to the Fish Barrier Dam (i.e., the Fish Barrier Pool), which comprised an area of 16 acres that accounted for 1 percent of the lower Feather River. River lamprey were infrequently observed from the Fish Barrier Dam to the confluence with the Sacramento River, which comprised an area of 2,994 acres that accounted for 99 percent of the lower Feather River (Figures 5.1-13 and 5.1-14).

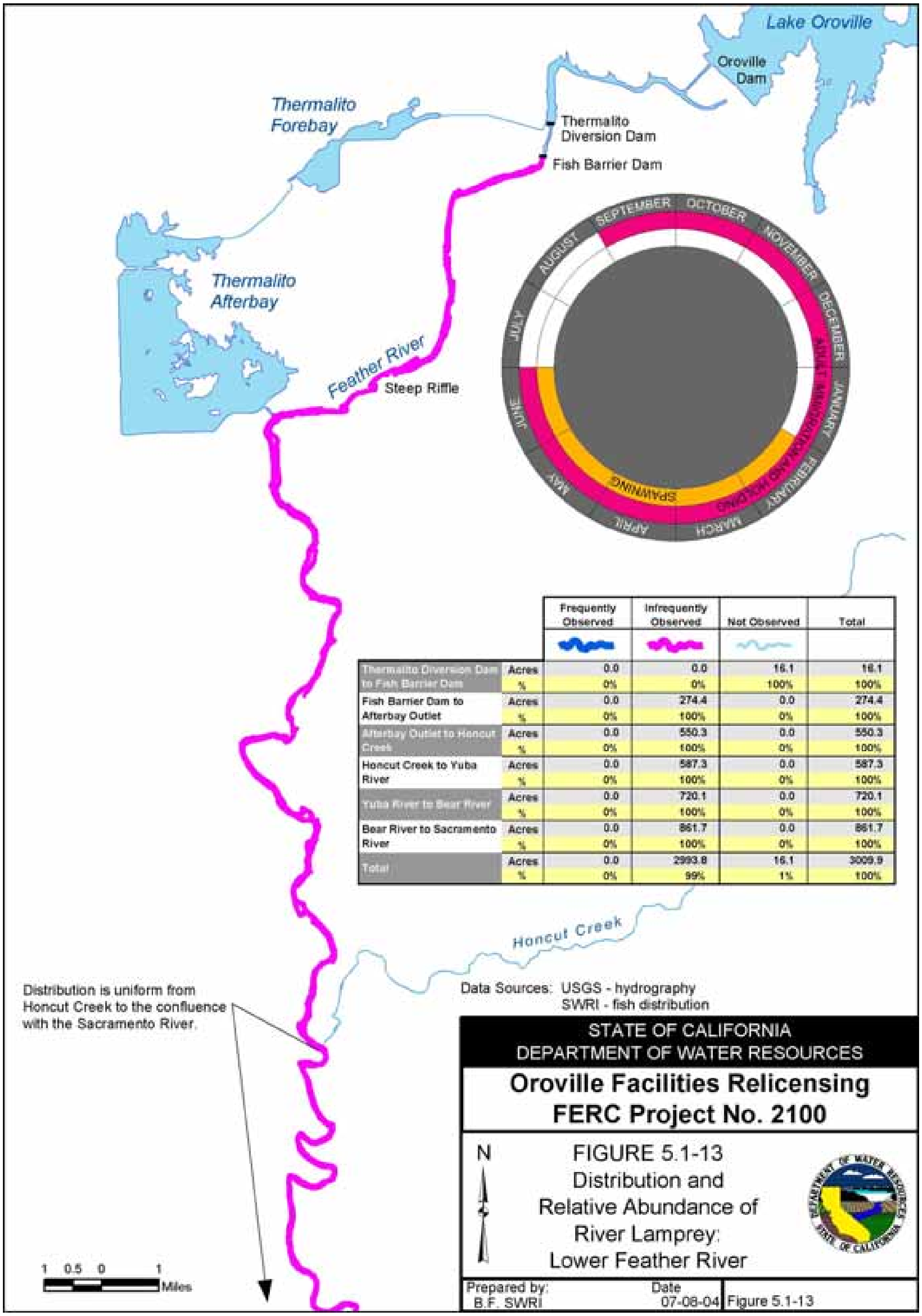


Figure 5.1-13. River lamprey distribution and relative abundance in the Feather River from the Fish Barrier Pool to the confluence with the Sacramento River.

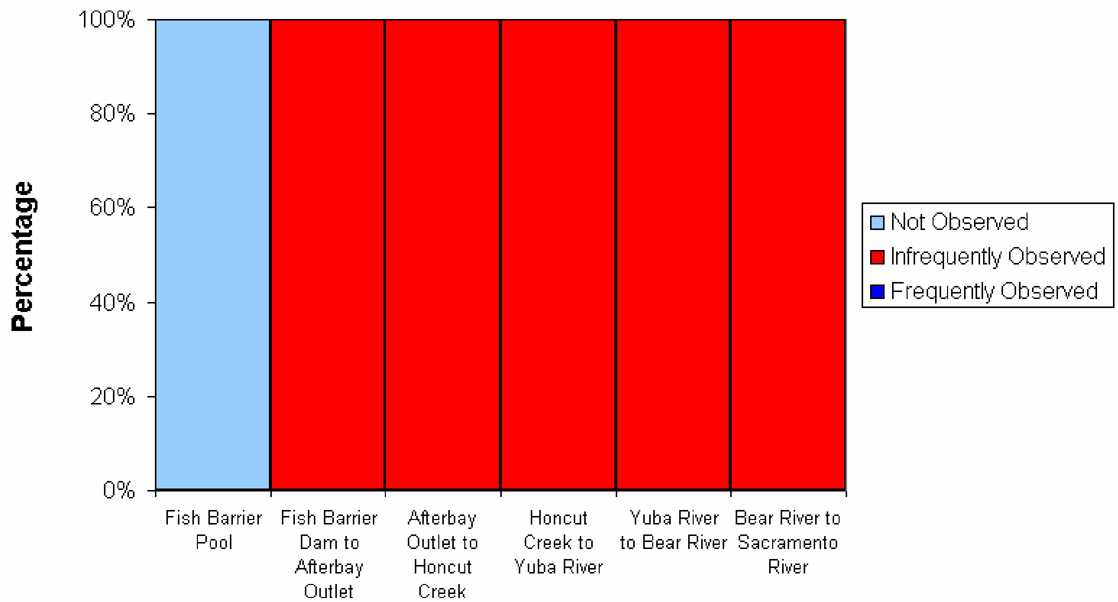
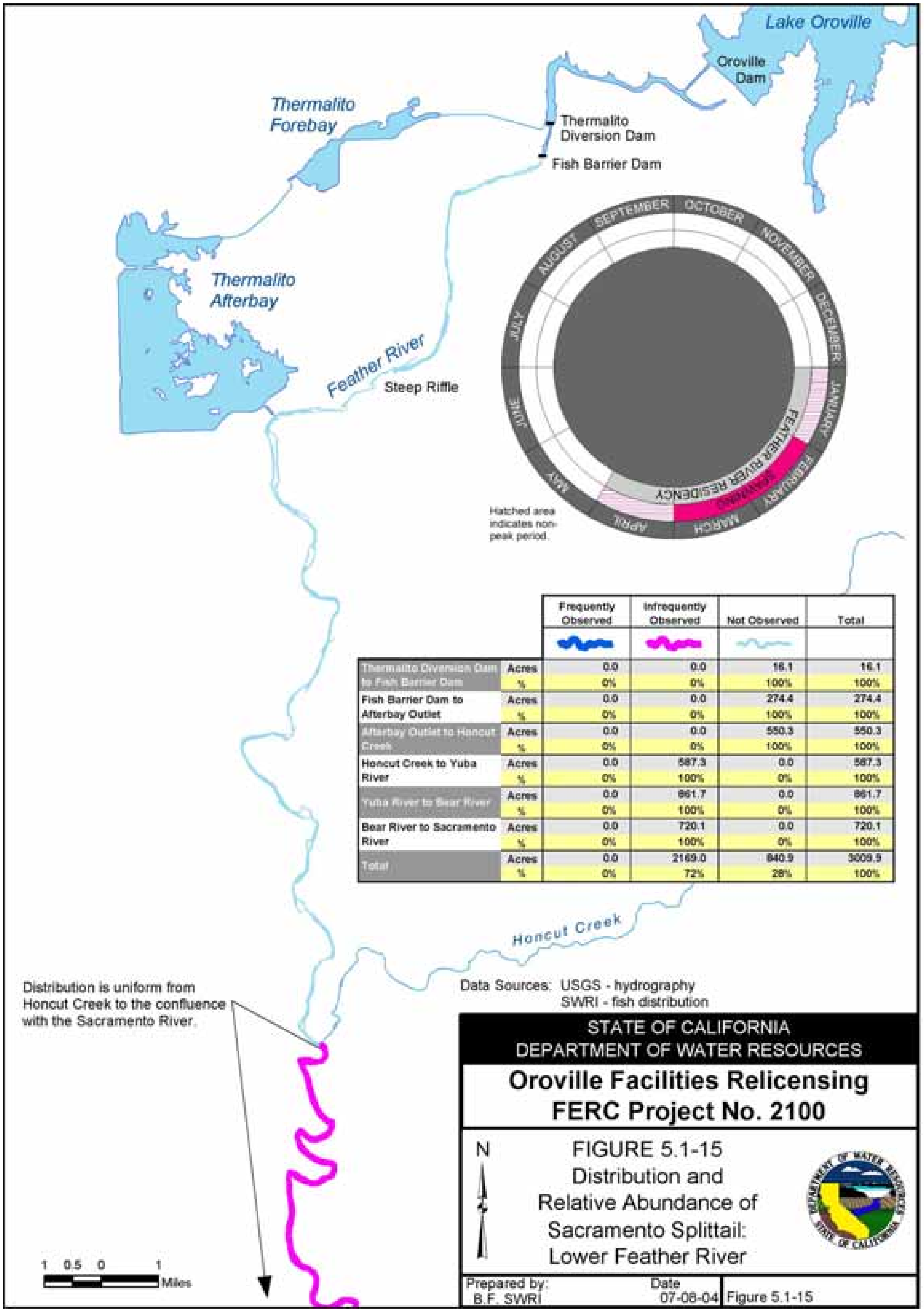


Figure 5.1-14. Proportions of relative abundance of River Lamprey by reach in the Feather River from the Fish Barrier Pool to the confluence with the Sacramento River.

5.1.3.8 Sacramento Splittail

Sacramento Splittail have not been observed from the Thermalito Diversion Dam to the confluence of the Feather River and Honcut Creek, which comprised 841 acres that accounted for 28 percent of the lower Feather River. This fish has been infrequently observed from the Honcut Creek down to the confluence with the Sacramento River, which corresponded to an area of 2,169 acres that accounted for 72 percent of the lower Feather River (Figures 5.1-15 and 5.1-16).



		Frequently Observed	Infrequently Observed	Not Observed	Total
Thermalito Diversion Dam to Fish Barrier Dam	Acres	0.0	0.0	16.1	16.1
	%	0%	0%	100%	100%
Fish Barrier Dam to Afterbay Outlet	Acres	0.0	0.0	274.4	274.4
	%	0%	0%	100%	100%
Afterbay Outlet to Honcut Creek	Acres	0.0	0.0	550.3	550.3
	%	0%	0%	100%	100%
Honcut Creek to Yuba River	Acres	0.0	587.3	0.0	587.3
	%	0%	100%	0%	100%
Yuba River to Bear River	Acres	0.0	861.7	0.0	861.7
	%	0%	100%	0%	100%
Bear River to Sacramento River	Acres	0.0	720.1	0.0	720.1
	%	0%	100%	0%	100%
Total	Acres	0.0	2169.0	840.9	3009.9
	%	0%	72%	28%	100%

Figure 5.1-15. Sacramento Splittail distribution and relative abundance in the Feather River from the Fish Barrier Pool to the confluence with the Sacramento River.

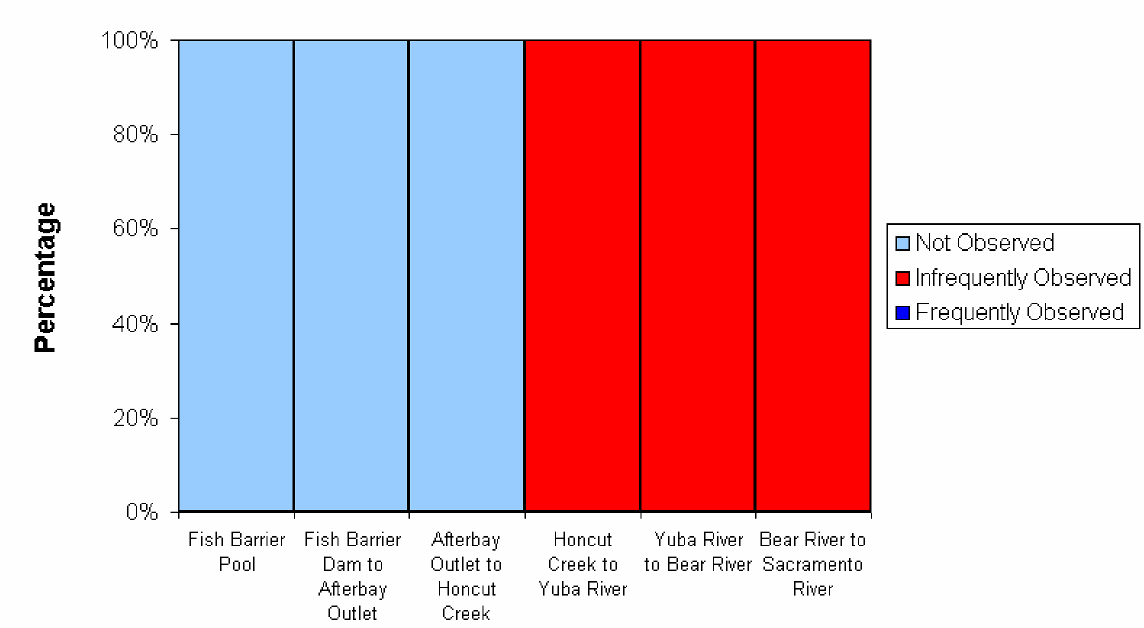
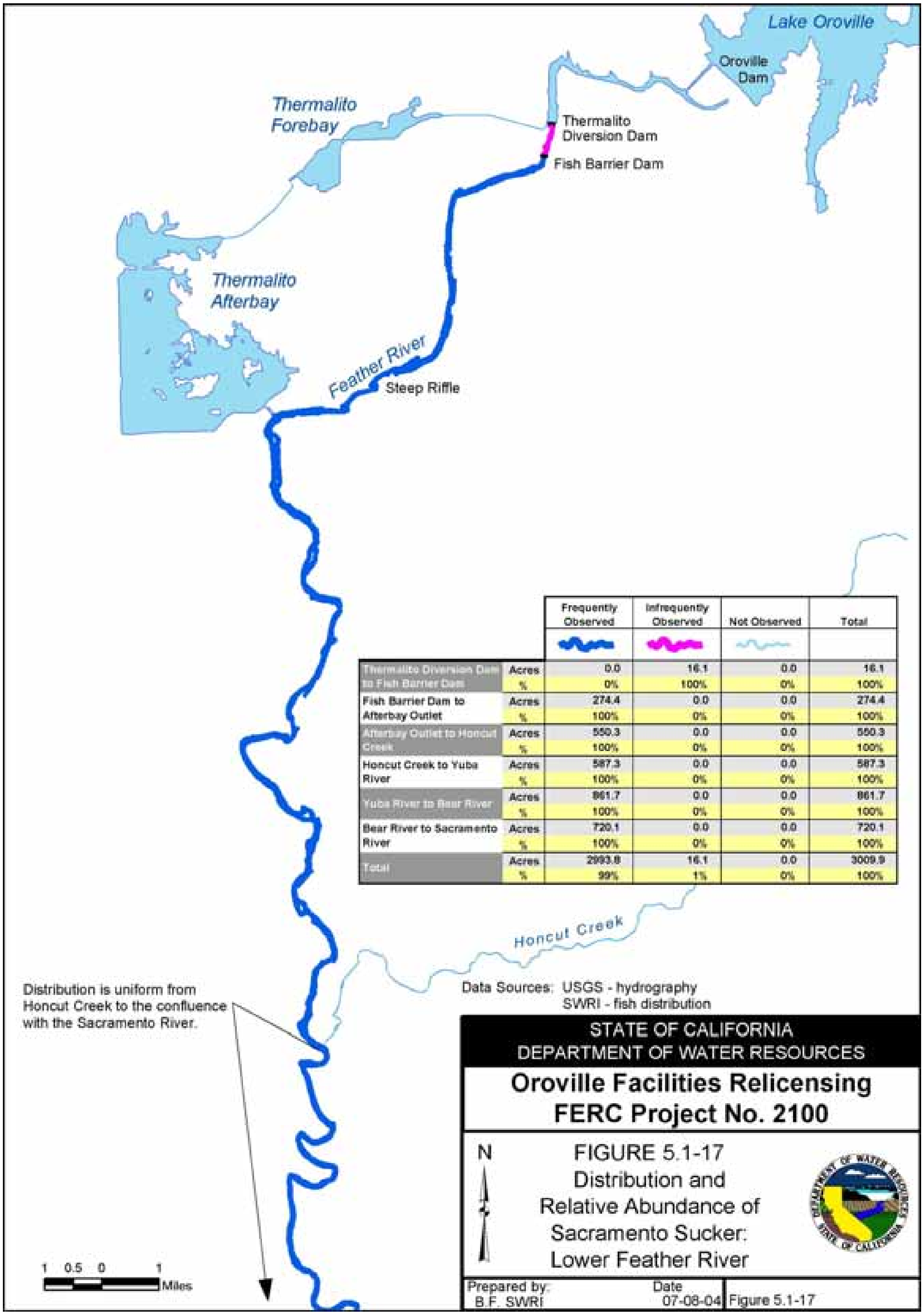


Figure 5.1-16. Proportions of relative abundance of Sacramento Splittail by reach in the Feather River from the Fish Barrier Pool to the confluence with the Sacramento River.

5.1.3.9 Sacramento Sucker

Sacramento sucker have been infrequently observed from the Thermalito Diversion Dam to the Fish Barrier Dam (i.e., the Fish Barrier Pool), which comprised an area of 16 acres that accounted for 1 percent of the lower Feather River. Sacramento sucker have frequently been observed from the Fish Barrier Dam to the confluence with the Sacramento River, which comprised an area of 2,994 acres that accounted for 99 percent of the lower Feather River (Figures 5.1-17 and 5.1-18).



		Frequently Observed	Infrequently Observed	Not Observed	Total
Thermalito Diversion Dam to Fish Barrier Dam	Acres	0.0	16.1	0.0	16.1
	%	0%	100%	0%	100%
Fish Barrier Dam to Afterbay Outlet	Acres	274.4	0.0	0.0	274.4
	%	100%	0%	0%	100%
Afterbay Outlet to Honcut Creek	Acres	550.3	0.0	0.0	550.3
	%	100%	0%	0%	100%
Honcut Creek to Yuba River	Acres	587.3	0.0	0.0	587.3
	%	100%	0%	0%	100%
Yuba River to Bear River	Acres	861.7	0.0	0.0	861.7
	%	100%	0%	0%	100%
Bear River to Sacramento River	Acres	720.1	0.0	0.0	720.1
	%	100%	0%	0%	100%
Total	Acres	2993.8	16.1	0.0	3009.9
	%	99%	1%	0%	100%

Figure 5.1-17. Sacramento Sucker distribution and relative abundance in the Feather River from the Fish Barrier Pool to the confluence with the Sacramento River.

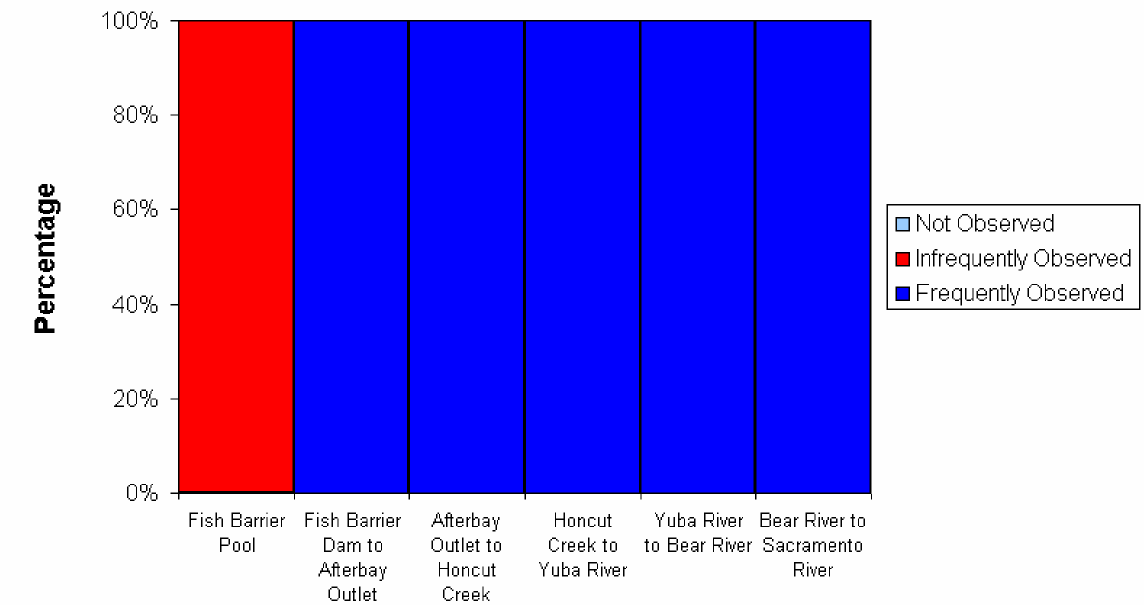
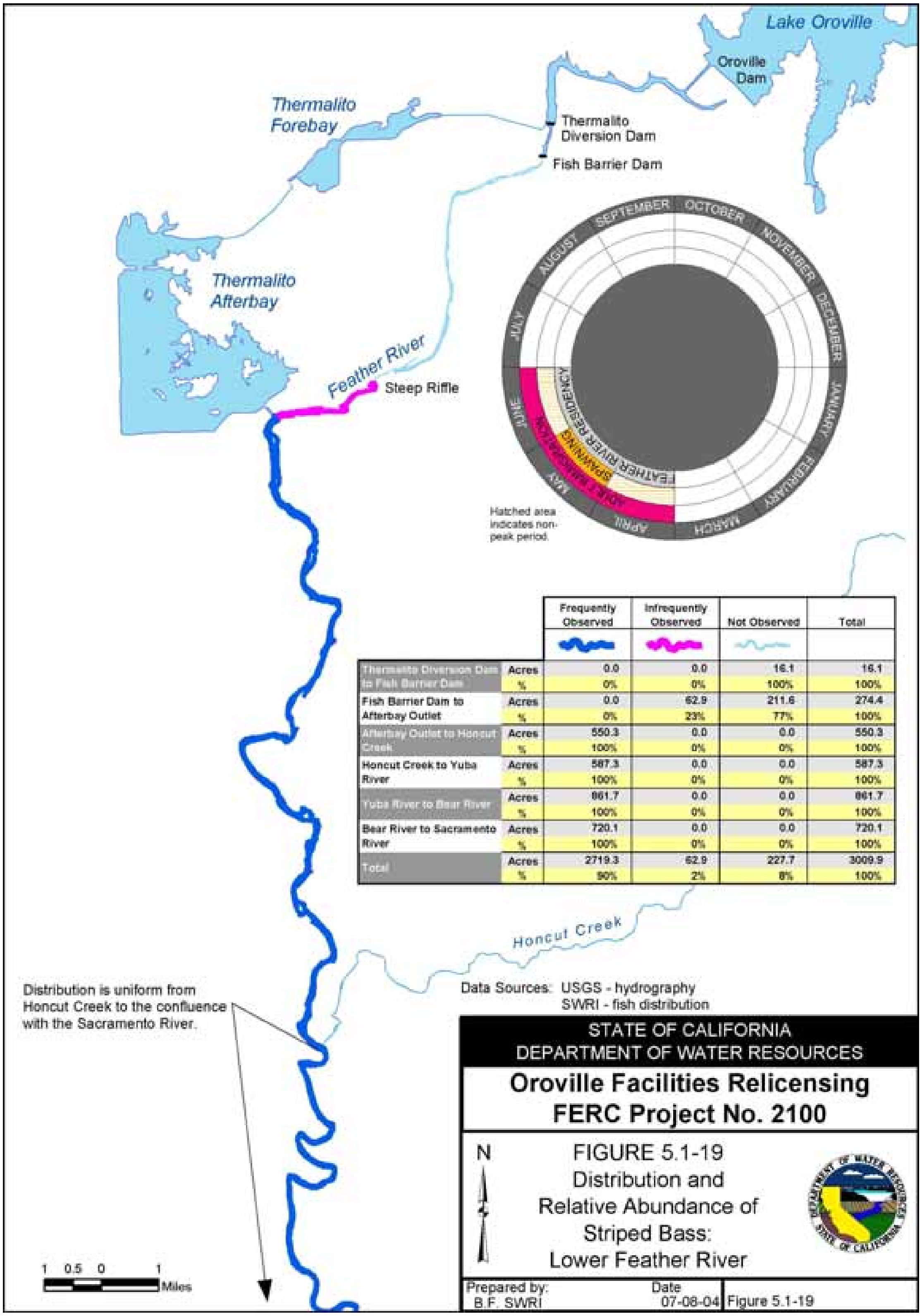


Figure 5.1-18. Proportions of relative abundance of Sacramento Sucker by reach in the Feather River from the Fish Barrier Pool to the confluence with the Sacramento River.

5.1.3.10 Striped Bass

Striped bass were not observed from the Thermalito Diversion Dam to Steep Riffle, which comprised an area of 228 acres that accounted for 8 percent of the lower Feather River. Striped bass were infrequently observed from Steep Riffle to the Thermalito Afterbay Outlet, which comprised an area of 63 acres that accounted for 2 percent of the lower Feather River. Additionally, striped bass have been frequently observed from the Thermalito Afterbay Outlet to the confluence with the Sacramento River, which comprised an area of 2,719 acres that accounted for 90 percent of the lower Feather River (Figures 5.1-19 and 5.1-20).



		Frequently Observed	Infrequently Observed	Not Observed	Total
Thermalito Diversion Dam to Fish Barrier Dam	Acres	0.0	0.0	16.1	16.1
	%	0%	0%	100%	100%
Fish Barrier Dam to Afterbay Outlet	Acres	0.0	62.9	211.6	274.4
	%	0%	23%	77%	100%
Afterbay Outlet to Honcut Creek	Acres	550.3	0.0	0.0	550.3
	%	100%	0%	0%	100%
Honcut Creek to Yuba River	Acres	587.3	0.0	0.0	587.3
	%	100%	0%	0%	100%
Yuba River to Bear River	Acres	861.7	0.0	0.0	861.7
	%	100%	0%	0%	100%
Bear River to Sacramento River	Acres	720.1	0.0	0.0	720.1
	%	100%	0%	0%	100%
Total	Acres	2719.3	62.9	227.7	3009.9
	%	90%	2%	8%	100%

Figure 5.1-19. Striped Bass distribution and relative abundance in the Feather River from the Fish Barrier Pool to the confluence with the Sacramento River.

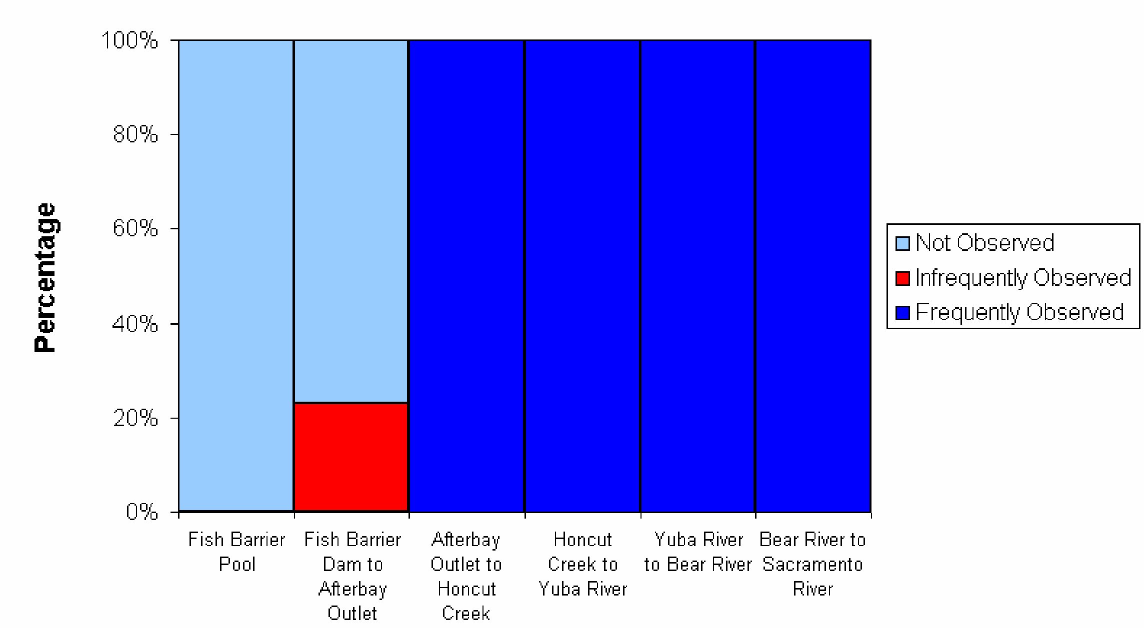
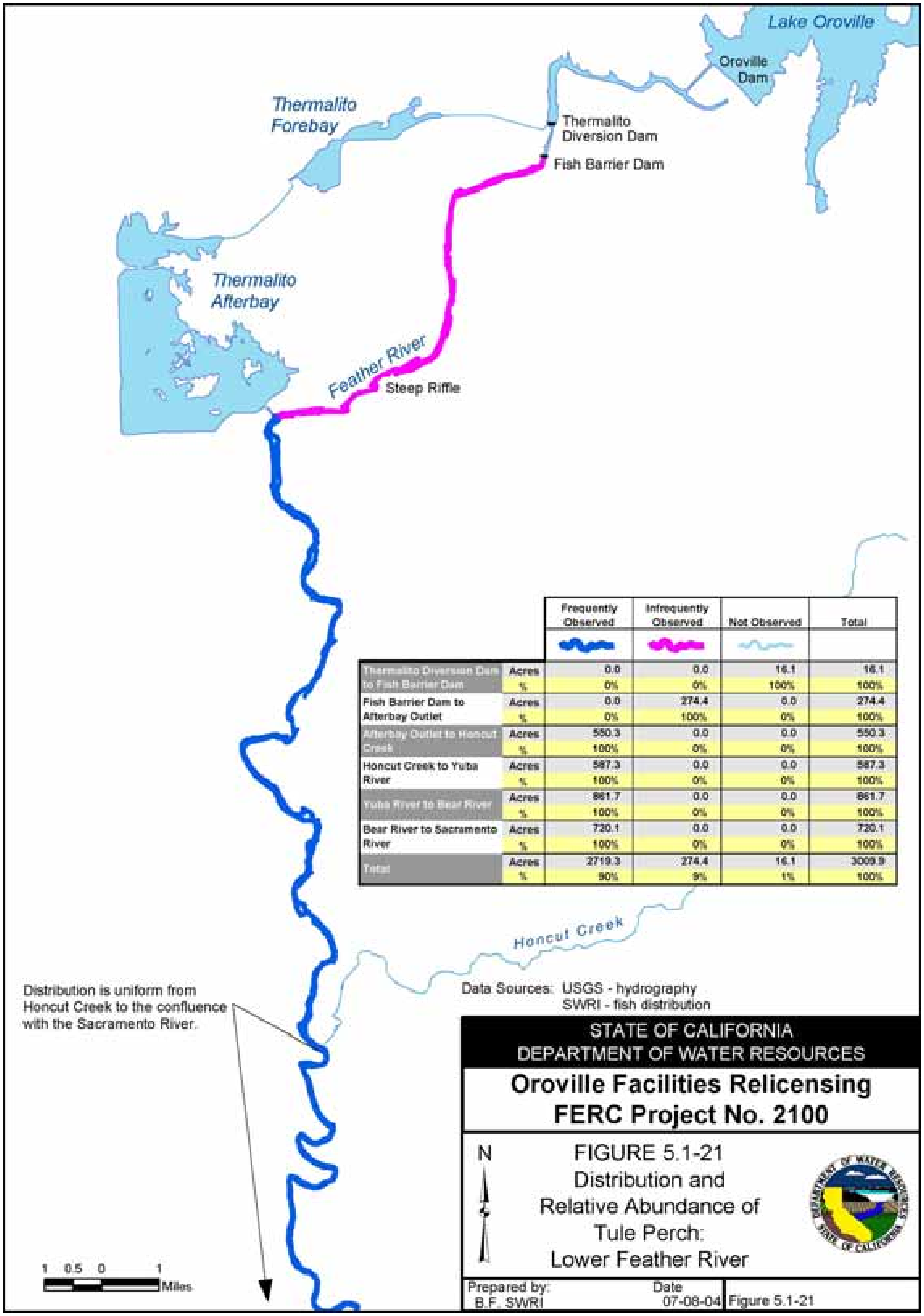


Figure 5.1-20. Proportions of relative abundance of Striped Bass by reach in the Feather River from the Fish Barrier Pool to the confluence with the Sacramento River.

5.1.3.11 Tule Perch

Tule Perch have not been observed from the Thermalito Diversion Dam to the Fish Barrier Dam, an area of 16 acres that accounted for 1 percent of the lower Feather River. Additionally, tule perch were infrequently observed between the Fish Barrier Dam and the Thermalito Afterbay Outlet, an area of 274 acres that accounted for 9 percent of the lower Feather River. The species was frequently observed from the Thermalito Afterbay Outlet to the confluence with the Sacramento River, an area of 2,719 acres that accounted for 90 percent of the lower Feather River (Figures 5.1-21 and 5.1-22).



		Frequently Observed	Infrequently Observed	Not Observed	Total
Thermalito Diversion Dam to Fish Barrier Dam	Acres	0.0	0.0	16.1	16.1
	%	0%	0%	100%	100%
Fish Barrier Dam to Afterbay Outlet	Acres	0.0	274.4	0.0	274.4
	%	0%	100%	0%	100%
Afterbay Outlet to Honcut Creek	Acres	550.3	0.0	0.0	550.3
	%	100%	0%	0%	100%
Honcut Creek to Yuba River	Acres	587.3	0.0	0.0	587.3
	%	100%	0%	0%	100%
Yuba River to Bear River	Acres	861.7	0.0	0.0	861.7
	%	100%	0%	0%	100%
Bear River to Sacramento River	Acres	720.1	0.0	0.0	720.1
	%	100%	0%	0%	100%
Total	Acres	2719.3	274.4	16.1	3009.9
	%	90%	9%	1%	100%

Figure 5.1-21. Tule Perch distribution and relative abundance in the Feather River from the Fish Barrier Pool to the confluence with the Sacramento River.

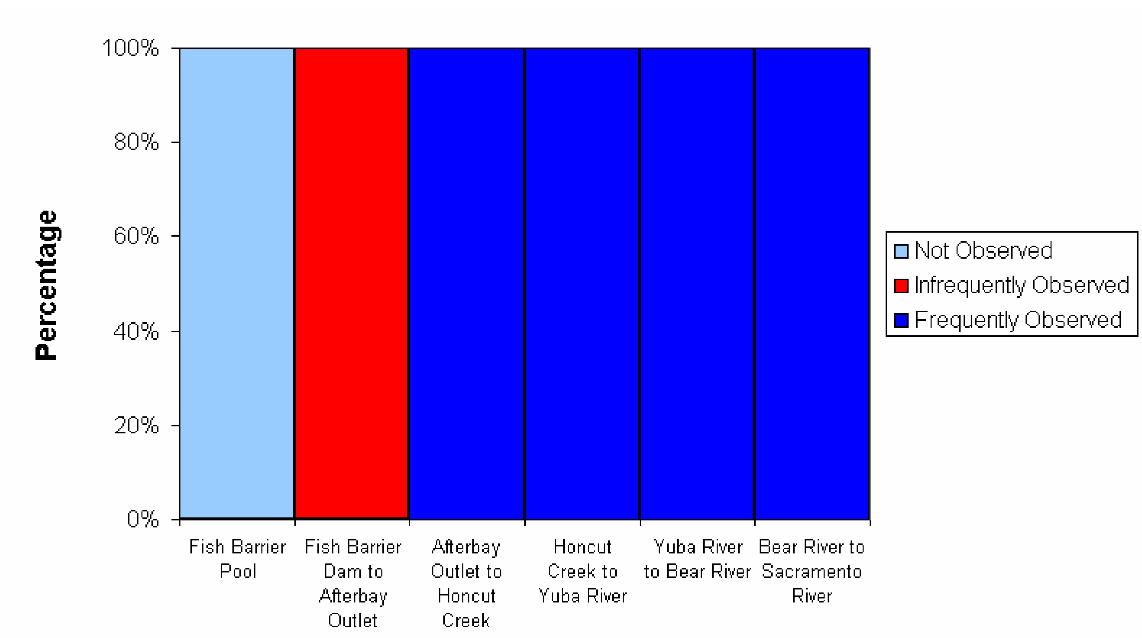


Figure 5.1-22. Proportions of relative abundance of Tule Perch by reach in the Feather River from the Fish Barrier Pool to the confluence with the Sacramento River.

5.3.1.12 Relative Abundance of Fish Species in the Lower Feather River

Hardhead, Sacramento pikeminnow, Pacific lamprey, and Sacramento sucker were frequently observed, while river lamprey were infrequently observed between the Thermalito Diversion Dam and the confluence of the Feather and Sacramento rivers, an area of 2,994 acres, which accounted for 99 percent of the mesohabitat of the lower Feather River (Table 5.1-2 and Figure 5.1-23). American Shad, all observed centrarchids, hitch, striped bass, and tule perch were frequently observed, while green sturgeon and white sturgeon were infrequently observed between the Thermalito Diversion Dam and the confluence of the Feather and Sacramento rivers, an area of 2,719 acres, which accounted for 90 percent of the mesohabitat of the Lower Feather River. Sacramento Splittail have been infrequently observed between the Thermalito Diversion Dam and the confluence of the Feather and Sacramento rivers, an area of 2,169 acres, which accounted for 72 percent of the mesohabitat of the Lower Feather River.

Table 5.1-2 Acres of fish distribution in the lower Feather River by fish species.

Species	Frequently Observed	Infrequently Observed	Not Observed
American Shad	2,719	623	228
Centrarchids	2,719	79	212
Green Sturgeon	0	2,719	291
Hardhead and Sacramento Pikeminnow	2,994	16	0

Species	Frequently Observed	Infrequently Observed	Not Observed
Hitch	2,719	0	291
Pacific Lamprey	2,994	0	16
River Lamprey	0	2,994	16
Sacramento Splittail	0	2,169	841
Sacramento Sucker	2,994	16	0
Striped Bass	2,719	63	228
Tule Perch	2,719	274	16
White Sturgeon	0	2,719	297

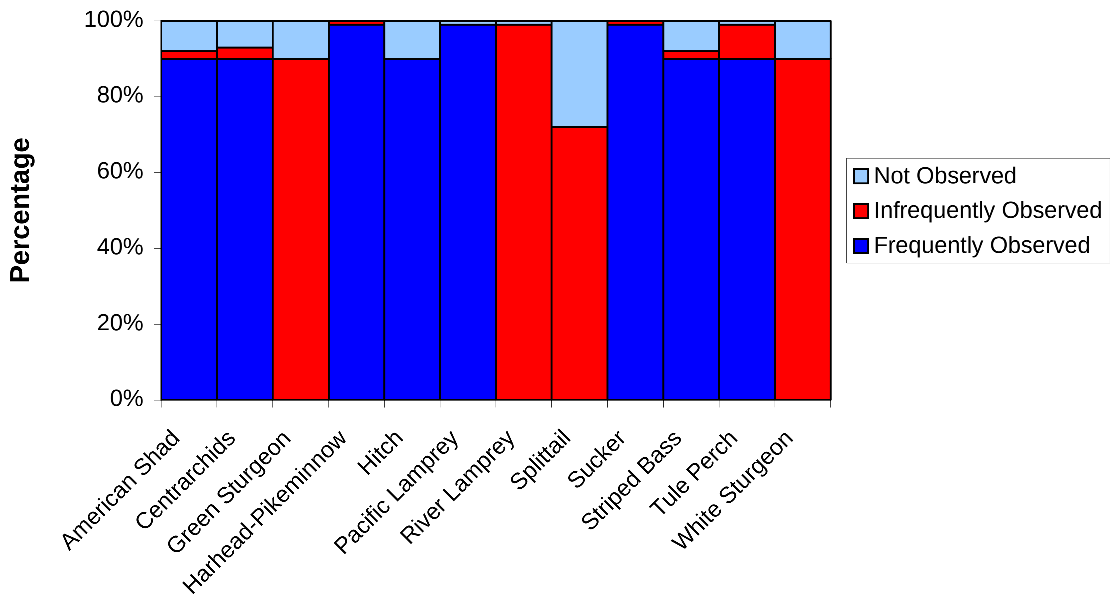


Figure 5.1-23. Relative abundance of fish in the lower Feather River by fish species.

5.1.4 Data Limitations

The definitions of fish distribution are necessarily generalized to represent the typical range of fish distribution, which can be dynamic, based on a combination of conditions. The definition of fish distribution is based on the synthesis of the fish distribution data sources, which have varying degrees of spatial, temporal, and abundance specificity. Additionally, DWR fisheries biologists incorporated their observations and professional judgment into the multimetric definition of fish species distribution and relative abundance. It should be noted that, for purposes of this analysis, abundance is specific to the relative number of fish observations within each species.

5.1.5 Data Use

The geographic definition of fish distribution is generalized and represents a range of potential presence, and the limitations associated with a generalized range of potential presence should be noted when analyzing the potential effects of water quality exceedance, habitat availability, etc. Thus, the conclusions drawn from analyses incorporating these generalized representations of fish distribution and relative abundance will be evaluated for the type of biases potentially introduced into the analyses.

5.2 FISH HABITAT COMPONENTS

5.2.1 Mesohabitat

5.2.1.1 Data Summary

Three hundred seven mesohabitat units were identified in the Feather River, from the Thermalito Diversion Dam to the confluence with the Sacramento River. Mesohabitat units ranged in size from approximately 0.01 acres (535 ft^2) to 708 acres, with a mean of 9.8 acres. Seventy-nine mesohabitat units were classified as glides, which occupied 2,190 acres (Table 5.2-1) and accounted for approximately 73 percent of the existing mesohabitats (Figure 5.2-1). Eighty mesohabitat units were identified as pools, which occupied an area of 552 acres that represented approximately 18 percent of available mesohabitats. Eighty-three riffles covered an area of 102 acres and represented approximately 3 percent of available habitat. Fifty-seven mesohabitat units were identified as backwater, which occupied 84 acres and represented approximately 3 percent of available habitat. Seven runs covered an area of 66 acres that represented approximately 2 percent of available habitat. One mesohabitat unit was identified as a boulder run with an area of 0.7 acres, which represented less than 0.1 percent of all available habitat.

Table 5.2-1. Mesohabitat area (acres) by reach in the lower Feather River.

Mesohabitat Type	Diversion Dam to Afterbay	Afterbay Outlet to Honcut Creek	Honcut Creek to Yuba River	Yuba River to Bear River	Bear River to Sacramento River
Run	5	2	59	0	0
Riffle	17	57	20	8	0
Pool	186	296	32	32	6
Glide	39	173	452	818	708
Boulder Run	1	0	0	0	0
Backwater	27	22	25	4	6

The proportion of glide mesohabitat types increased with increased distance downstream, eventually comprising almost 100 percent of the mesohabitat types (Figure 5.2-2). Specifically, the proportion of glide mesohabitat types increased rapidly from the confluence of the Feather River and Honcut Creek downstream to the confluence of the Feather and Sacramento rivers. Pools were prevalent from the Thermalito Diversion Dam to Honcut Creek.

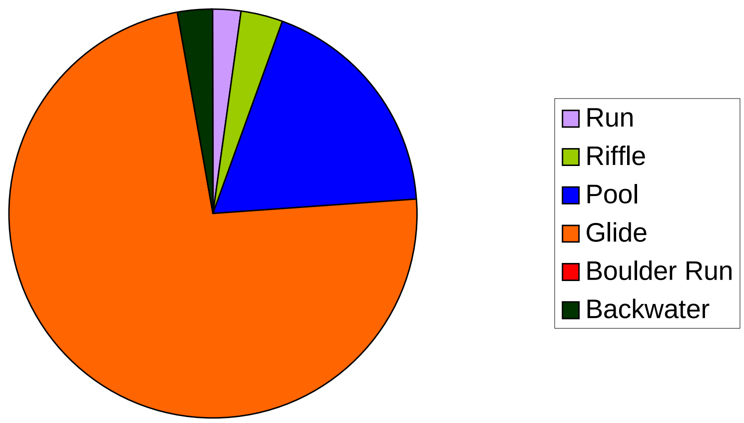


Figure 5.2-1. Percentage of mesohabitat types in the Feather River from the Thermalito Diversion Dam to the confluence with the Sacramento River.

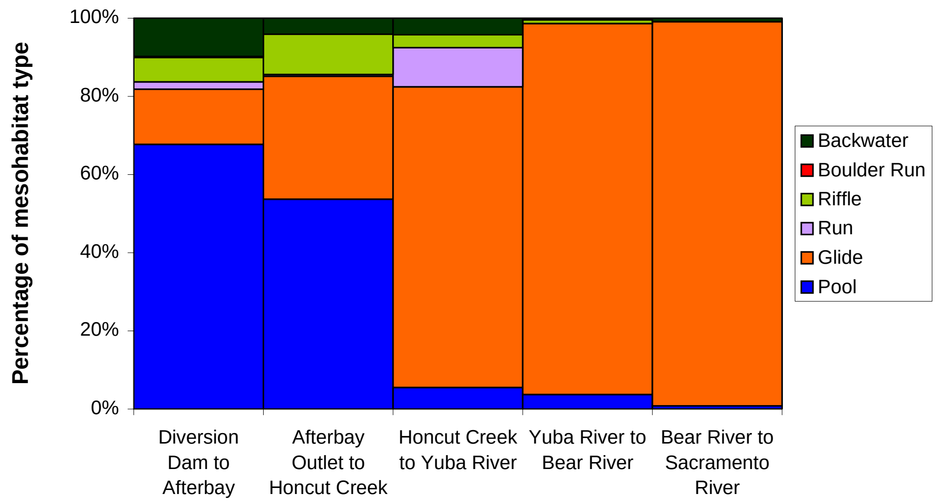


Figure 5.2-2. Percentage of mesohabitat type by reach in the Feather River from the Thermalito Diversion Dam to the confluence with the Sacramento River.

Between the Thermalito Diversion Dam and the Thermalito Afterbay Outlet, the most abundant mesohabitat units were pools, which occupied 186 acres and represented approximately 68 percent of all mesohabitat in the reach. Glides occupied an area of 39 acres and represented approximately 14 percent of mesohabitat in the reach. Backwaters covered an area of 27 acres and represented approximately 10 percent of mesohabitat within the reach. Riffles covered an area of 17 acres and represented approximately 6 percent of mesohabitat within the reach. Runs covered an area of 5 acres, which corresponded to approximately 2 percent of mesohabitat within the reach. The least abundant mesohabitat type between the Thermalito Diversion Dam and the Thermalito Afterbay Outlet was boulder run, which occupied 0.7 acres and represented 0.3 percent of mesohabitat within the reach (Figure 5.2-3).

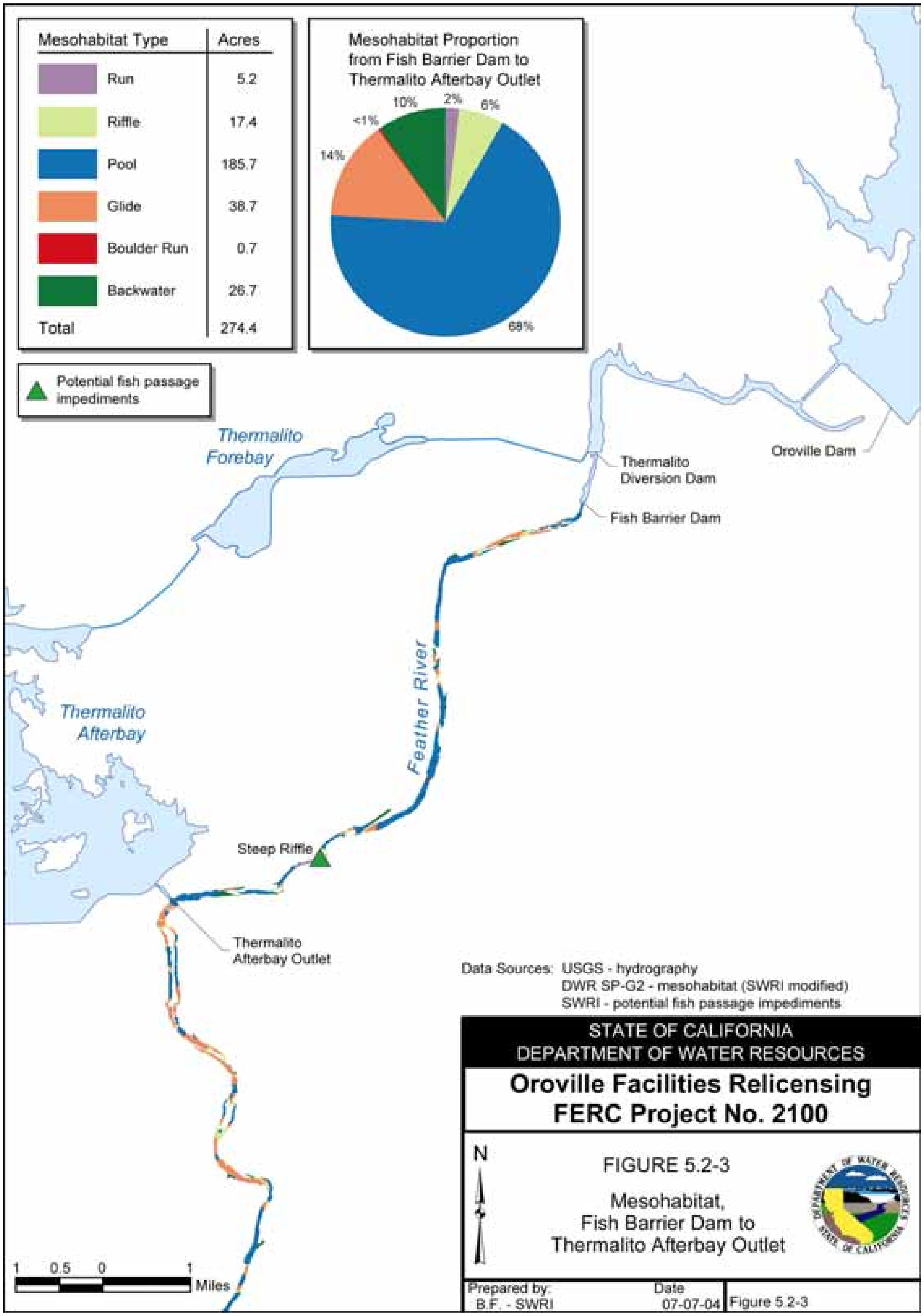


Figure 5.2-3. Mesohabitat in the lower Feather River from Thermalito Diversion Dam to the Afterbay Outlet.

Between the Thermalito Afterbay Outlet and Honcut Creek, the most abundant mesohabitat unit was pool, which occupied 296 acres and represented approximately 54 percent of mesohabitat within the reach. Glides occupied an area of 173 acres, which represented approximately 31 percent of the mesohabitat within the reach. Riffles covered an area of 57 acres and represented approximately 10 percent of the mesohabitat within the reach. Backwaters covered an area of 22 acres and represented approximately 4 percent of the mesohabitat within the reach. Runs covered 2 acres, which corresponded to approximately 0.4 percent of mesohabitat from the Thermalito Afterbay Outlet to Honcut Creek. No boulder runs were present within the reach (Figure 5.2-4).

Between Honcut Creek and the Yuba River, the most abundant mesohabitat type was glide, which occupied 452 acres and represented approximately 77 percent of the mesohabitat within the reach. Runs occupied an area of 59 acres and represented approximately 10 percent of the mesohabitat within the reach. Pools covered an area of 32 acres and represented approximately 6 percent of the mesohabitat within the reach. Backwater covered an area of 25 acres and represented approximately 4 percent of the mesohabitat within the reach. Riffles covered an area of 20 acres, which corresponded to approximately 3 percent of the mesohabitat from Honcut Creek to the Yuba River. No boulder runs were present within the reach (Figure 5.2-5).

Between the Yuba River and the Bear River, the most abundant mesohabitat type was glide, which occupied 818 acres and represented approximately 95 percent of the mesohabitat within the reach. Pools covered an area of 32 acres and represented approximately 4 percent of the mesohabitat within the reach. Backwaters covered an area of 4 acres and represented approximately 0.4 percent of the mesohabitat within the reach. Riffles covered an area of 8 acres, which corresponded to approximately 1 percent of the mesohabitat between the Yuba River and the Bear River. No runs or boulder runs were present within the reach (Figure 5.2-6).

Between the Bear River and the Sacramento River, the most abundant mesohabitat type was glide, which occupied 708 acres and represented approximately 98 percent of the mesohabitat within the reach. Backwaters covered an area of 6 acres and represented approximately 1 percent of the mesohabitat within the reach while pools covered an area of 6 acres and represented approximately 1 percent of the mesohabitat within the reach. No riffles, runs, or boulder runs were present between the Bear River and the Sacramento River (Figure 5.2-7).

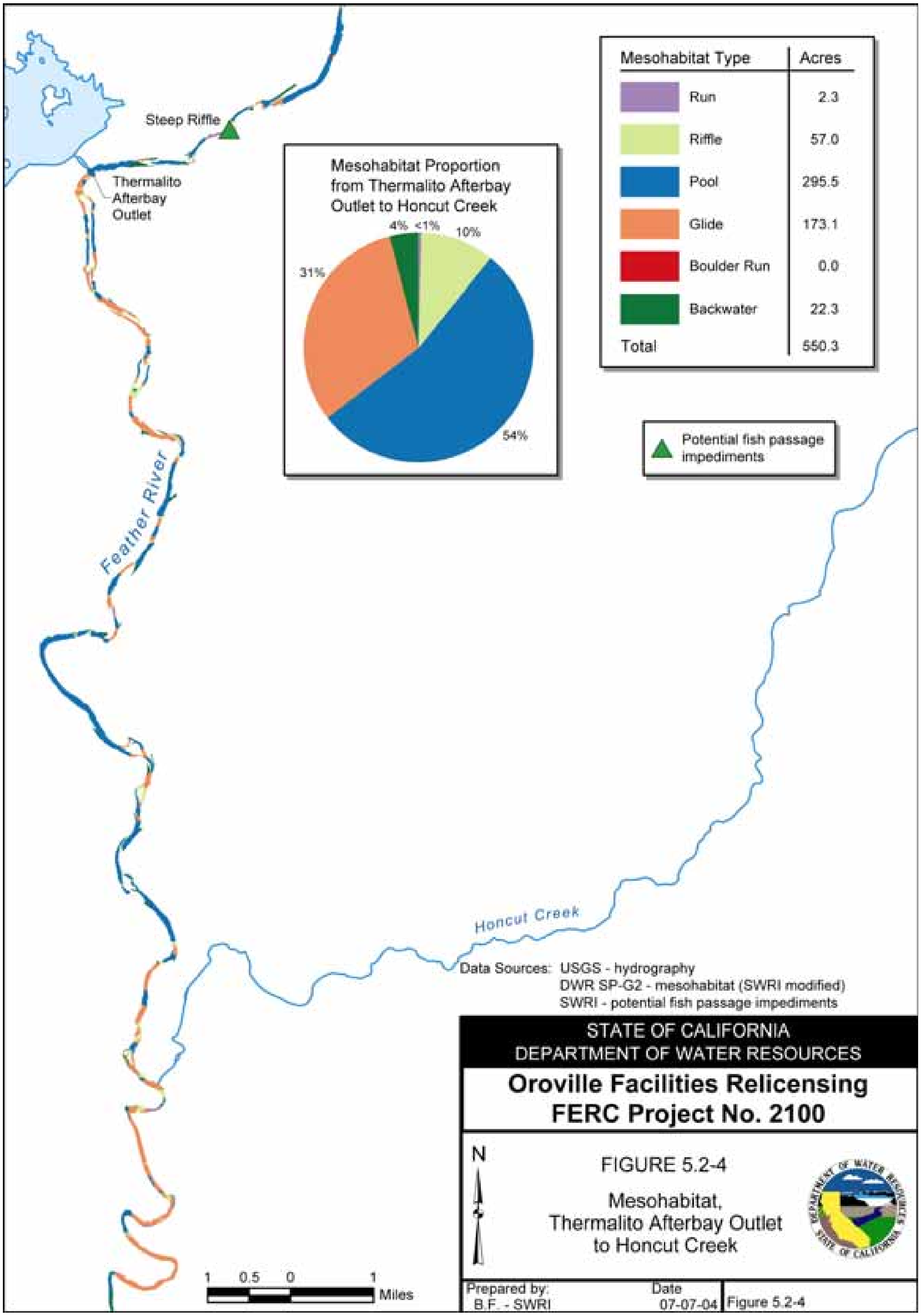


Figure 5.2-4. Mesohabitat in the lower Feather River from the Afterbay Outlet to Honcut Creek.

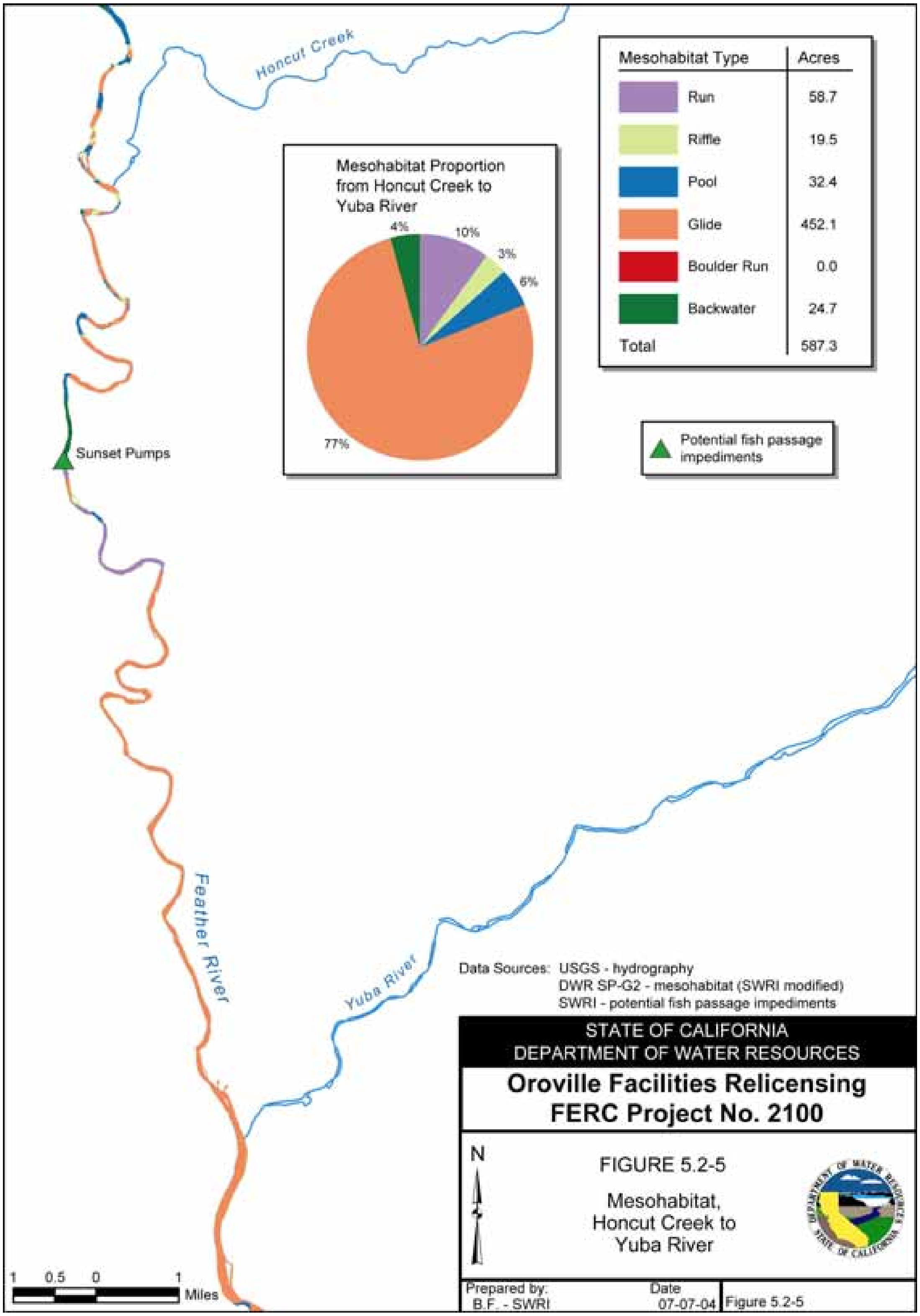


Figure 5.2-5. Mesohabitat in the lower Feather River from Honcut Creek to Yuba River.

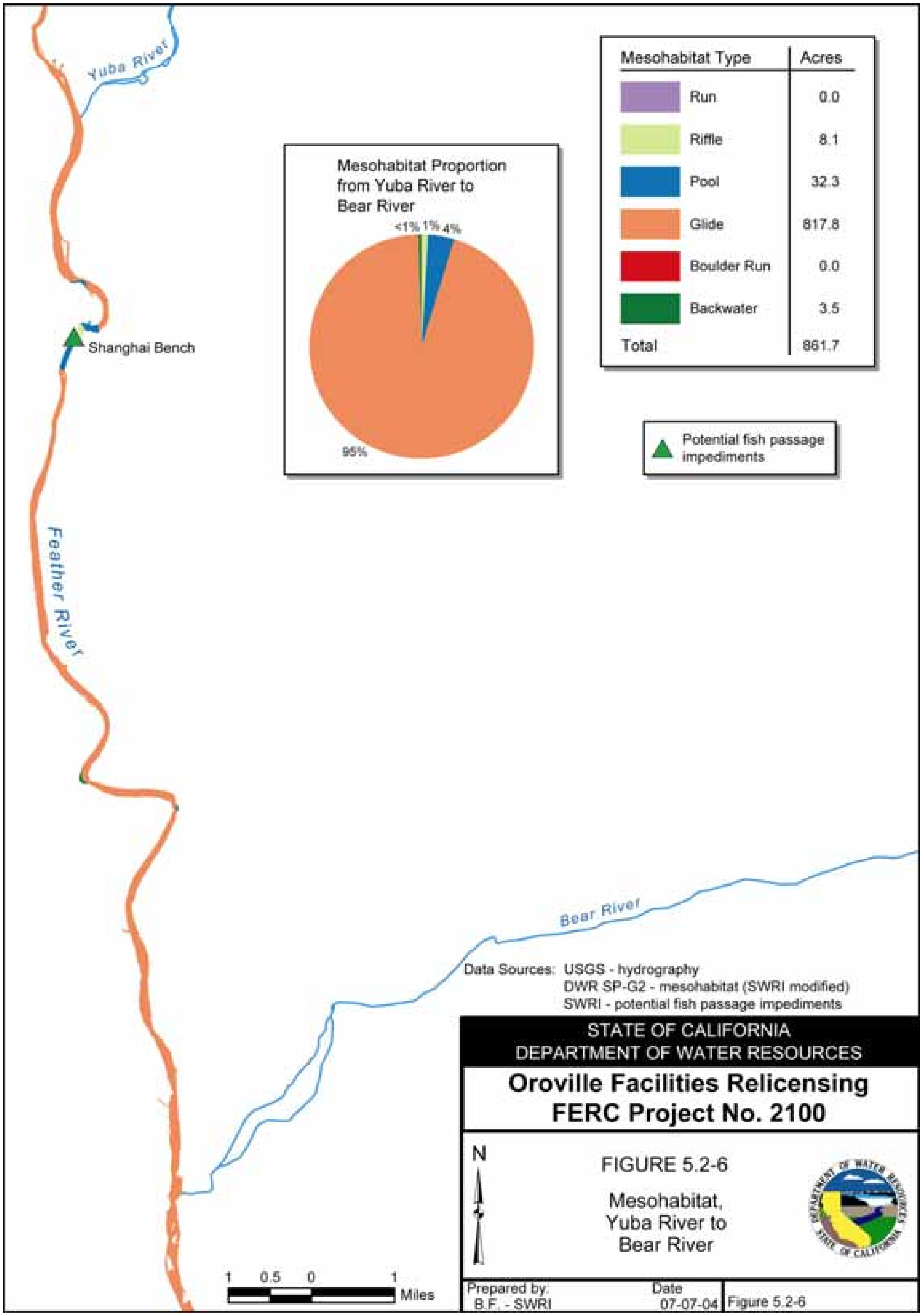


Figure 5.2-6. Mesohabitat in the lower Feather River from Yuba River to Bear River.

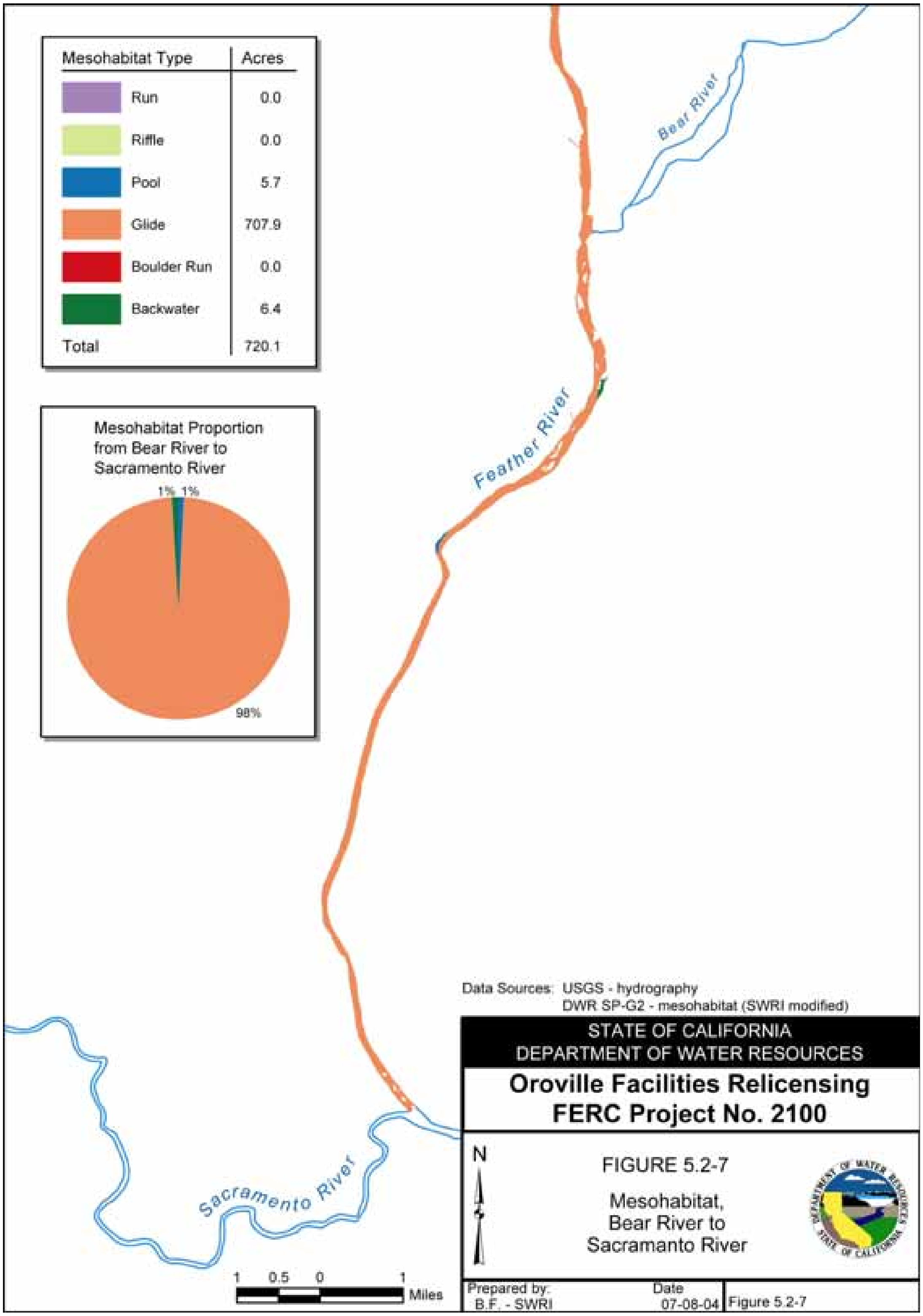


Figure 5.2-7. Mesohabitat in the lower Feather River from Bear River to the confluence with the Sacramento River.

5.2.1.2 Data Limitations

Although no major flow events have occurred since the acquisition of the DOQQ source images, some gravel movement and changes to instream features have occurred. The mesohabitat classification system utilized also was designed to minimize subjectivity associated with different flows in the identification of the habitat units, but some subjective professional judgment was required. Therefore, classification of mesohabitat units was, to some degree, dependent on flows at the time of observation.

Changes in the locations of some instream features due to the vintage of the source aerial photography as well as the limitations of the horizontal positional accuracy of the DOQQ data set (plus or minus 33.3 feet) limited the compatibility of the mesohabitat data set (and all of the data defined as attributes to the mesohabitat) with data that was spatially defined based on a different reference base (e.g., GPS coordinates) or from different vintage aerial photography interpreted data sets.

5.2.1.3 Data Use

Mesohabitat classifications were generalizations of the range of hydraulic conditions (water velocity, turbulence, etc.) observed between hydraulic controls. Within each mesohabitat unit there would be a diverse set of hydraulic conditions due to diverse geomorphologic conditions that create velocity refuges and back currents. Fish were assumed to move through all mesohabitat types utilizing velocity refuges and other unique site conditions within a mesohabitat unit that would otherwise not be suitable. The fish habitat classification selected those mesohabitat unit types that fish would primarily utilize for extended periods and excluded those mesohabitat types that would typically be uncharacteristic of the fish habitat requirements. Therefore, mesohabitat units that would primarily be utilized as transit corridors, or part-time foraging or predator avoidance areas were excluded as suitable mesohabitat types.

5.2.2 Substrate

5.2.2.1 Data Summary

No substrate was identified for twenty-three mesohabitat units while three units were identified as having an “unknown” substrate. The remaining 281 units were attributed with one, two, or three substrate types. Where multiple substrate types were identified within a single unit, the proportion of each substrate type generally was not defined. The dominant or co-dominant substrate classes usually were identified.

The relative proportion of substrate type changed from upstream to downstream. Table 5.2-2 and Figure 5.2-8 show the change in substrate type by reach. Increases in the proportion of fine substrates (i.e., sand and silt/clay) and decreases in the proportion of larger substrates (i.e., cobble) with increased distance downstream are evident in the lower Feather River, particularly below Honcut Creek.

Table 5.2-2. Substrate acreage by reach in the lower Feather River.

Reach	Bedrock Acres	Boulder Acres	Cobble Acres	Gravel Acres	Sand Acres	Silt/Clay Acres
Diversion Dam to Afterbay Outlet	39	11	199	191	10	11
Afterbay Outlet to Honcut Creek	0	0	333	350	3	6
Honcut Creek to Yuba River	0	4	5	535	21	357
Yuba River to Bear River	8	0	24	179	105	183
Bear River to Sacramento River	0	0	0	0	238	6

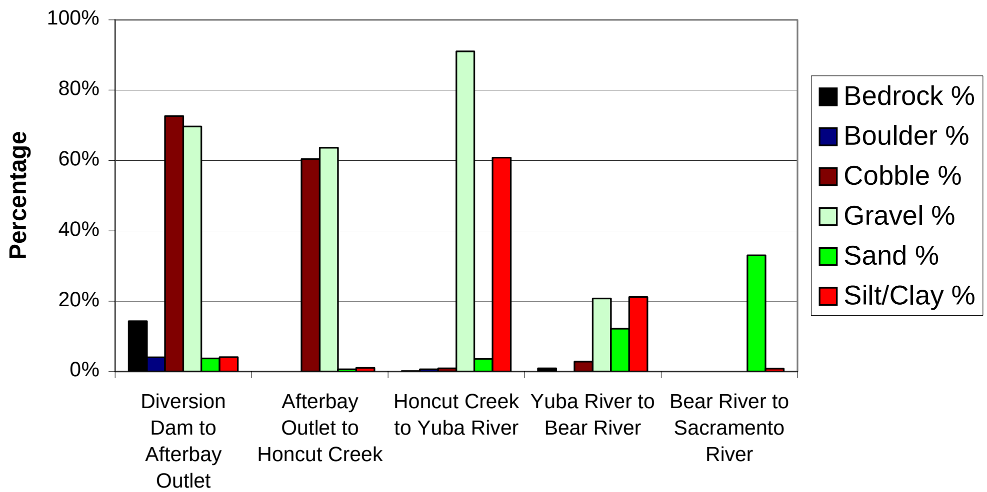


Figure 5.2-8. Substrate proportions by reach in the lower Feather River from the Diversion Dam to the confluence with the Sacramento River.

Between the Thermalito Diversion Dam and the Thermalito Afterbay Outlet, the most abundant substrates were cobble and gravel, which comprised 199 acres and 191 acres (Table 5.2-2), and represented 73 percent and approximately 70 percent of the reach acreage, respectively. Bedrock comprised 39 acres, which represented approximately 14 percent of the substrate within reach. Boulders, sand, and silt/clay comprised 11 acres, 10 acres, and 11 acres, respectively, which accounted for approximately 4 percent of the substrate classes within the reach (Figure 5.2-8).

Between the Thermalito Afterbay Outlet and Honcut Creek, the most abundant substrates were cobble and gravel, which covered 333 acres and 350 acres (Table 5.2-2), respectively, and which represented approximately 60 percent and 64 percent of the reach acreage, respectively. Bedrock and boulder substrates were not found within this reach. Sand and silt/clay covered 3 acres and 6 acres, respectively, which accounted for approximately 1 percent for each of the substrate classes between the Thermalito Afterbay Outlet and Honcut Creek (Figure 5.2-8).

Between Honcut Creek and the Yuba River, the most abundant substrates were gravel and silt/clay, which covered 535 acres and 357 acres (Table 5.2-2), respectively, and which represented approximately 91 percent and 61 percent, respectively of the reach acreage. Bedrock and boulder substrates covered 1 acre and 4 acres, respectively, which represented 0.1 percent and 0.6 percent, respectively of the substrate within the reach. Cobble and sand were present and covered 5 acres and 21 acres, respectively, which accounted for 1 percent and 4 percent of the total substrate between Honcut Creek and the Yuba River (Figure 5.2-8).

Between the Yuba River and the Bear River, the most abundant substrates were silt/clay and gravel, which covered 183 acres and 179 acres (Table 5.2-2), respectively, and which represented approximately 21 percent and 21 percent, respectively of the reach acreage. Bedrock covered 8 acres, which represented approximately 1 percent of the substrate within the reach. Boulder substrate was not found within the reach. Sand and cobble were present and covered 105 acres and 24 acres, respectively, which accounted for approximately 12 percent and 3 percent, respectively of the total substrate between the Yuba and Bear rivers (Figure 5.2-8).

Between the Bear River and the Sacramento River, the most abundant substrate was sand, which covered 238 acres (Table 5.2-2), which represented approximately 33 percent of the reach acreage. Bedrock, boulder, cobble, and sand were not found within the reach. Silt/clay was present and covered 6 acres, which accounted for approximately 1 percent of the total substrate on this reach (Figure 5.2-8). The substrate in the remainder of the reach was classified as unknown.

5.2.2.2 Data Limitations

The mesohabitat units are generally large and likely encompass a diverse set of substrate types. The potential diversity of substrate types within each mesohabitat unit is further complicated by variability in dominance of substrate type, component proportions of each substrate type, and uniform distribution of substrates within a mesohabitat unit.

5.2.2.3 Data Use

For each species, suitable substrate habitat component characteristics were defined. The relevance of substrate type as habitat component criteria is variable from species to species. If any substrate type determined to be suitable was present in a mesohabitat unit, the unit was considered to be potentially suitable. By excluding only those units where suitable substrate types were completely absent, the intent was to identify all potentially suitable habitats for each fish species.

5.2.3 Water Depth

5.2.3.1 Data Summary

Three hundred seven mesohabitat units were identified in the lower Feather River with water depths that varied from 1 ft to 38 ft deep, with a mean water depth of 4.4 ft. Water depths were divided into strata based on the average mesohabitat unit depth. Mesohabitat units with average depths that fell within the shallowest water depth stratum, between the surface (zero ft) and 2 ft, covered 110 acres (Table 5.2-3), which accounted for approximately 4 percent of the river area between the Thermalito Diversion Dam and the Sacramento River (Figure 5.2-9). Mesohabitat units with average depths between 2.1 ft and 4 ft covered 184 acres, which accounted for approximately 6 percent of all mesohabitats. Mesohabitat units with average water depths between 4.1 ft and 6 ft covered 972 acres, which accounted for approximately 33 percent of all mesohabitats. Water depth strata between 6.1 ft and 8 ft covered 1,526 acres, which accounted for approximately 51 percent of all mesohabitats. Mesohabitat units with average water depths between 8.1 ft and 10 ft covered 110 acres, which accounted for approximately 4 percent of all mesohabitats. Mesohabitat units with an average water depth deeper than 10 ft covered 93 acres, which accounted for approximately 3 percent of all mesohabitats. Table 5.2-3 shows the acreage of each water depth stratum in each reach in the lower Feather River.

Table 5.2-3. Water depth (ft) strata acreage by reach in the Feather River, from Thermalito Diversion Dam to the confluence with the Sacramento River.

Water depth strata (feet)	Thermalito Diversion Dam to Afterbay	Afterbay Outlet to Honcut Creek	Honcut Creek to Yuba River	Yuba River to Bear River	Bear River to Sacramento River
0-2.0	24	60	20	0	6
2.1-4.0	34	136	6	8	0
4.1-6.0	72	185	76	639	0
6.1-8.0	37	150	432	200	708
8.1-10.0	55	16	33	0	6
>10.0	52	4	21	15	0

Mesohabitat units within the shallow depth strata, between 1 ft and 4 ft, accounted for 21 percent, 36 percent, 4 percent, 1 percent, and 1 percent of the area within each of the five reaches from upstream to downstream, respectively. Mesohabitat units within the deepest strata (i.e., deeper than 8 ft) generally were restricted to the reaches upstream from the Bear River (Figure 5.2-10). Table 5.2-3 shows that mesohabitat units within the 4.1 ft to 6 ft stratum and within the 6.1 ft to 8 ft stratum were most abundant with the proportion of mesohabitat units within those strata increasing with increased distance downstream.

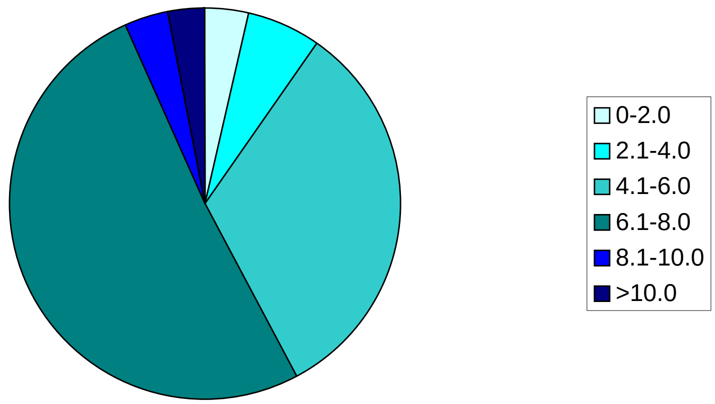


Figure 5.2-9. Proportions of water depth strata (ft) in the Feather River from the Thermalito Diversion Dam to the confluence with the Sacramento River.

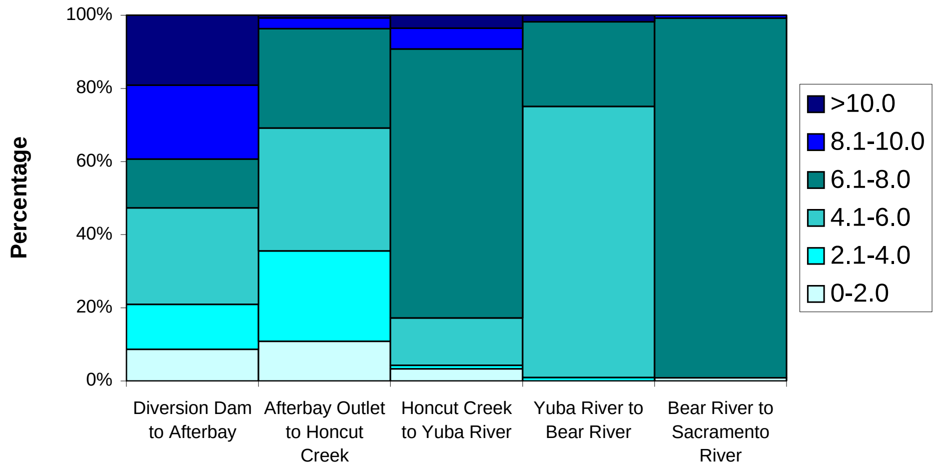


Figure 5.2-10. Proportions of water (ft) depth strata by reach in the Feather River from the Thermalito Diversion Dam to the confluence with the Sacramento River.

Between the Thermalito Diversion Dam and the Thermalito Afterbay Outlet, the most abundant water depth stratum was the stratum that represented water depths between 4.1 and 6 ft, which covered 72 acres that represented approximately 26 percent of the reach. Depth strata representing depths of 8.1 ft to 10 ft, and deeper than 10 feet covered 55 acres and 56 acres, respectively, which represented approximately 20 percent and 19 percent, respectively of habitat within the reach. Depth strata representing depths of 2.1 ft to 4 ft, and 6.1 ft to 8 ft occupied 34 acres and 37 acres, respectively, which represented approximately 12 percent and 13 percent, respectively, of the reach. The shallowest water depth stratum, representing mesohabitat units with an average depth between the water surface and 2 ft, covered 24 acres, which represented approximately 9 percent of the reach between the Thermalito Diversion Dam and the Thermalito Afterbay Outlet (Figure 5.2-11).

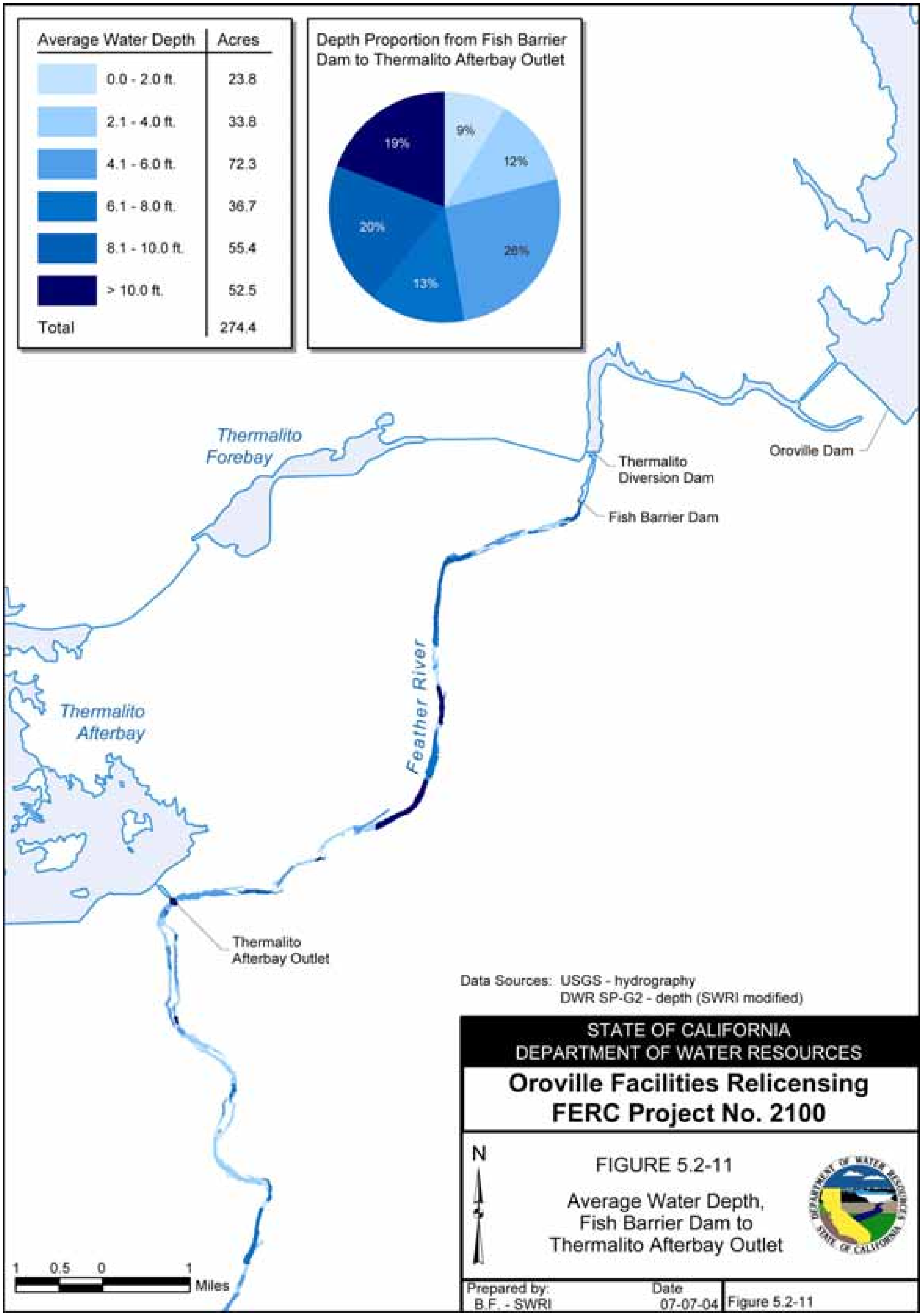


Figure 5.2-11. Water depth in the lower Feather River from the Diversion Dam to Afterbay Outlet.

Between the Afterbay Outlet and Honcut Creek, the most abundant water depth stratum was the depth stratum that represented water depths from 4.1 ft to 6 ft, which comprised 185 acres that represented approximately 34 percent of the reach. Depth strata representing mesohabitat units with average depths of 6.1 to 8 feet, and 2.1 to 4 feet occupied 150 acres and 136 acres, respectively, which represented approximately 27 percent and 25 percent, respectively of the habitat within the reach. The shallowest water depth stratum, representing mesohabitat units with an average depth between the water surface and 2 ft, occupied 60 acres, which represented approximately 11 percent of the habitat within the reach. Depth strata that represented water depths of 8.1 to 10 feet, and deeper than 10 feet comprised 16 acres and 4 acres, respectively, which represented approximately 3 percent and 1 percent, respectively of the habitat within the reach (Figure 5.2-12).

Between Honcut Creek and the Yuba River, the most abundant water depth stratum was the depth stratum that represented water depths from 6.1 ft to 8 ft, which comprised 432 acres that represented approximately 74 percent of the reach. The depth stratum that represented mesohabitat units with an average depth of 4.1 ft to 6 ft comprised 76 acres, which represented approximately 13 percent of the habitat within the reach. Depth strata that represented depths of 8.1 ft to 10 feet, and deeper than 10 feet comprised 33 acres and 21 acres, respectively, which represented approximately 6 percent and 4 percent, respectively, of the habitat within the reach. Shallowest depth strata representing water depths of 0 ft to 2 feet, and 2.1 ft to 4 feet comprised 20 acres and 6 acres, respectively, which represented approximately 3 percent and 1 percent, respectively of the habitat between Honcut Creek and the Yuba River (Figure 5.2-13).

Between the Yuba River and the Bear River, the most abundant water depth stratum was the stratum representing mesohabitat units with a depth ranging from 4.1 ft to 6 ft, which comprised 639 acres that represented approximately 74 percent of the habitat within the reach. The depth stratum representing water depths of 6.1 ft to 8 feet comprised 200 acres, which represented approximately 23 percent of the habitat within the reach. The depth stratum representing water deeper than 10 feet comprised 15 acres, which represented 2 percent of the habitat within the reach. The depth stratum representing depths between 2.1 ft and 4 ft comprised 8 acres, which represented approximately 1 percent of the habitat on this reach. No depth strata representing mesohabitat types with average depths between 0 ft and 2 ft, and between 8.1 ft and 10 ft were mapped between the Yuba River and the Bear River (Figure 5.2-14).

Between the Bear River and the confluence of the Feather and Sacramento rivers, the most abundant water depth stratum was the stratum that represented mesohabitat units with an average depth between 6.1 ft and 8 ft, which comprised 708 acres and represented approximately 98 percent of the habitat within the reach. Depth strata representing mesohabitat units with depths of 6.1 ft to 8 ft and 0 ft to 2 ft occupied 6 acres each, which represents approximately 1 percent of the habitat each within the reach (Figure 5.2-15).

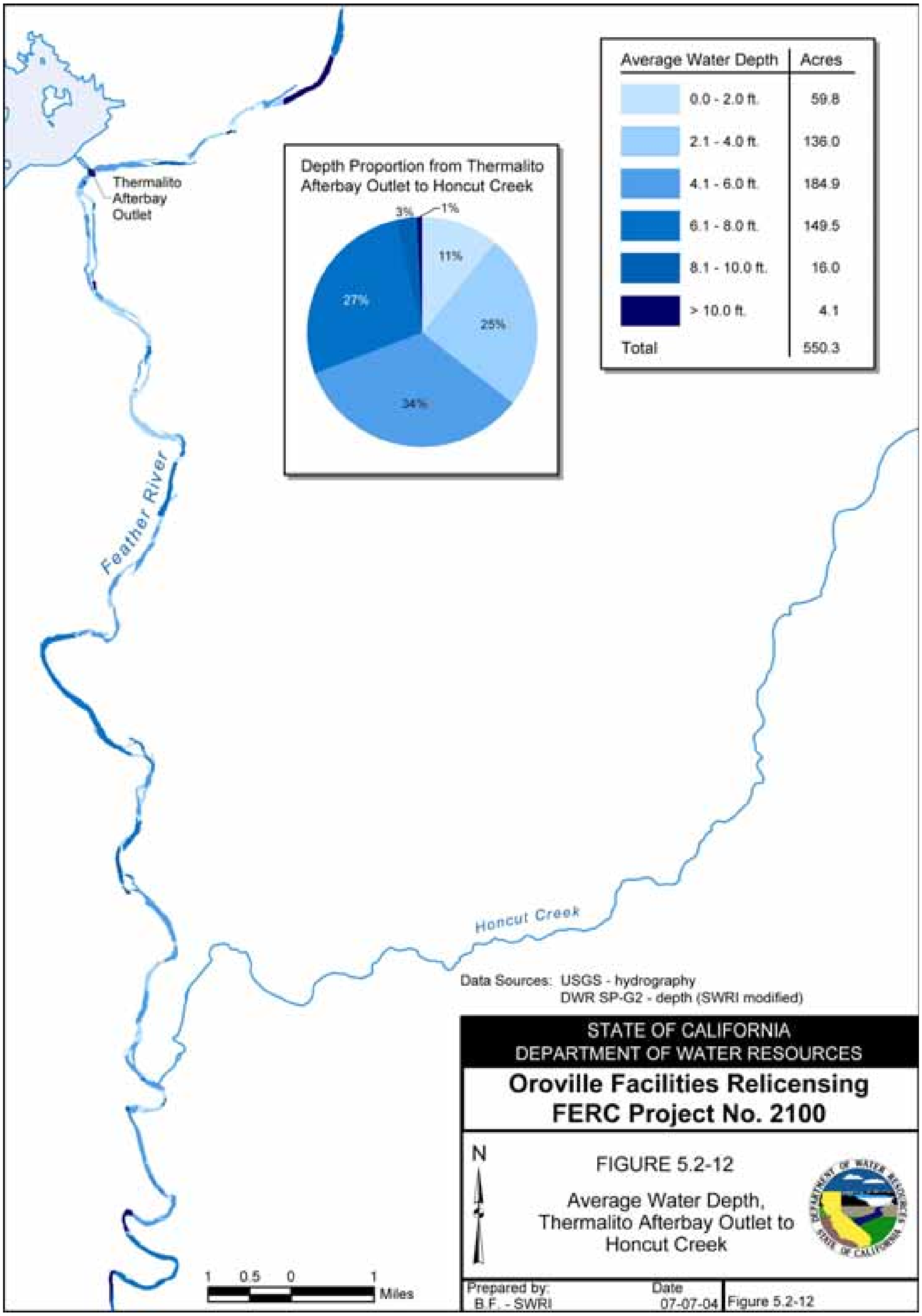


Figure 5.2-12. Water depth in the lower Feather River from the Afterbay Outlet to Honcut Creek.

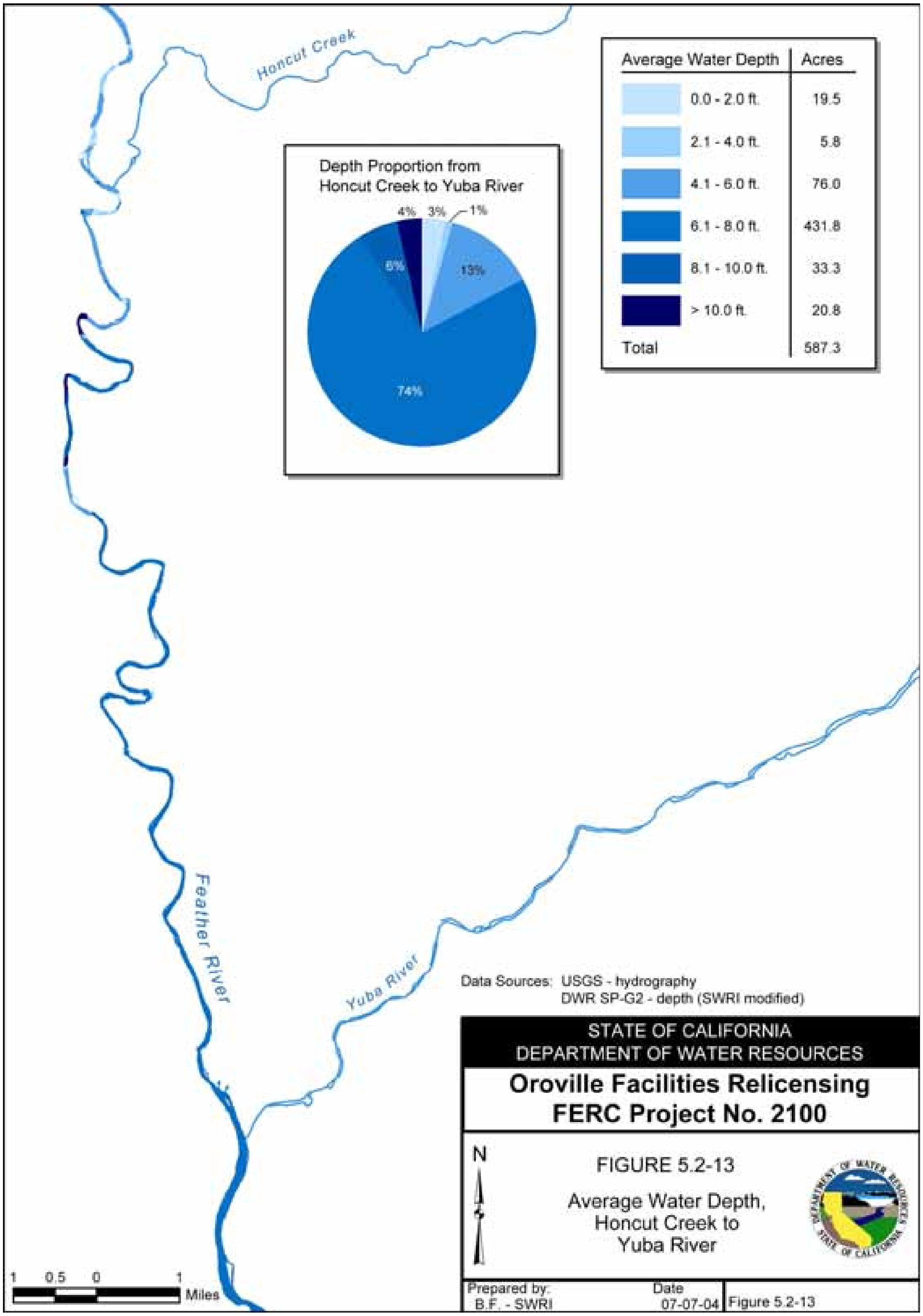


Figure 5.2-13. Water depth in the lower Feather River from Honcut Creek to the Yuba River.

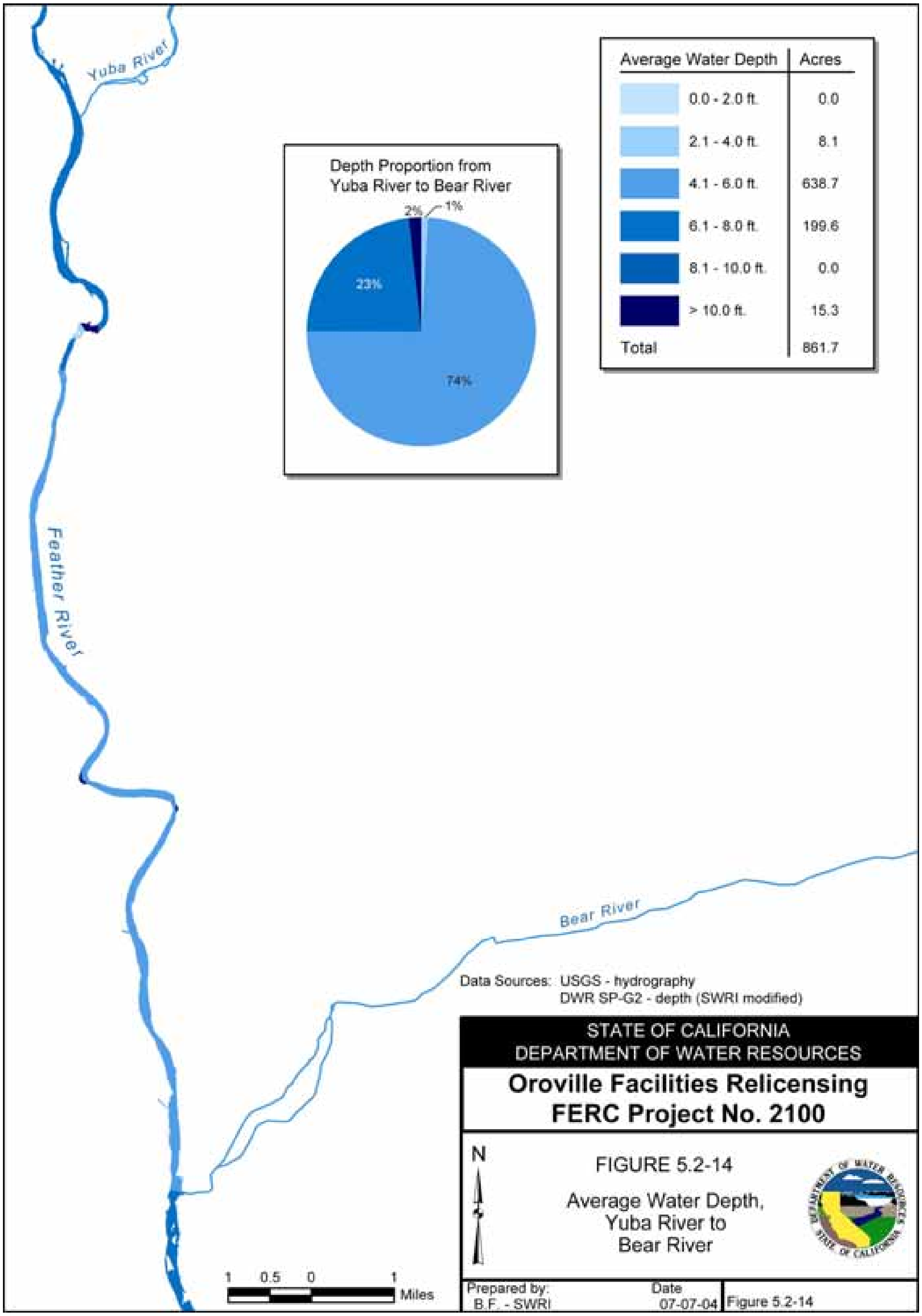


Figure 5.2-14. Water depth in the lower Feather River from the Yuba River to Bear River.

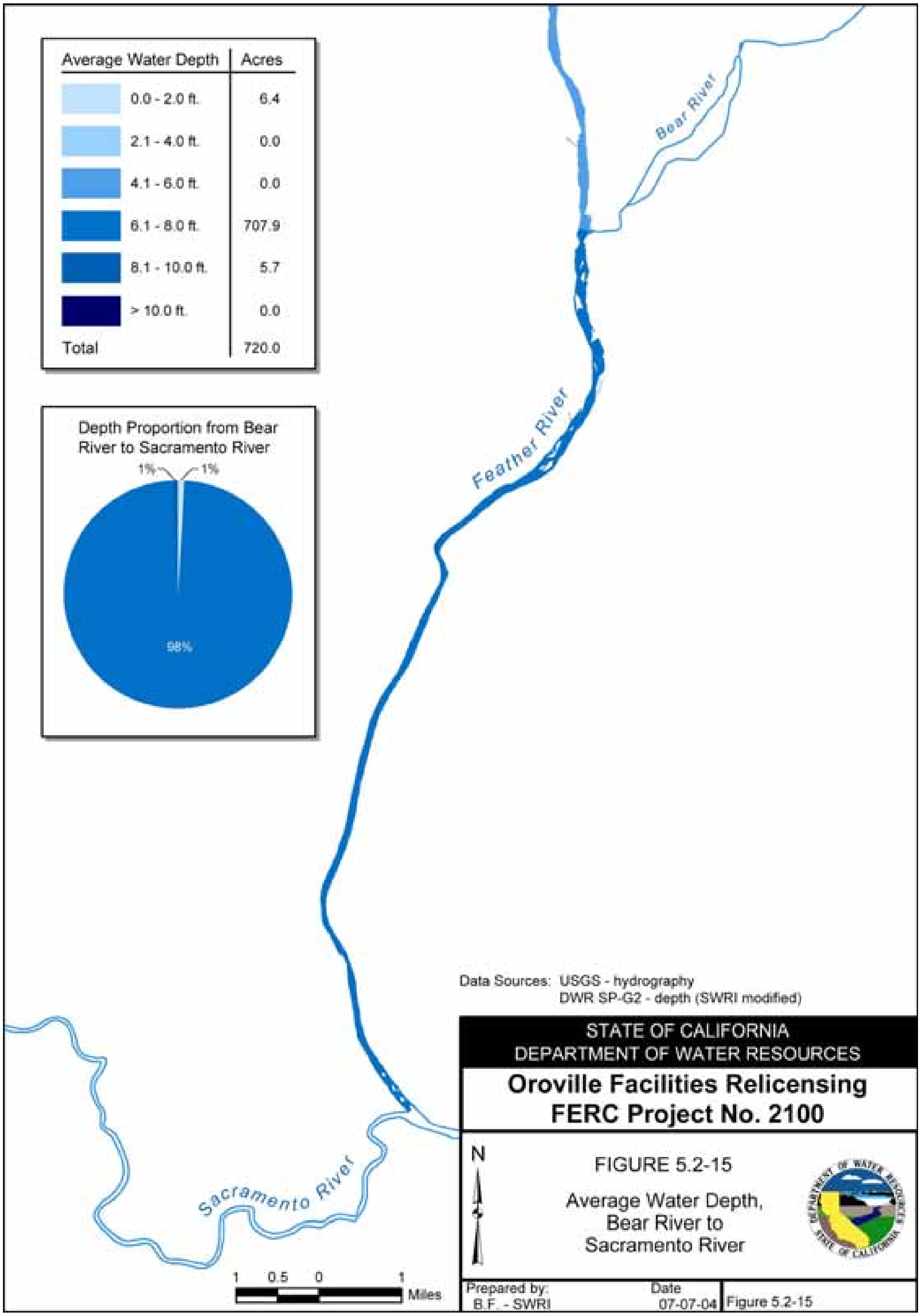


Figure 5.2-15. Water depth in the lower Feather River from Bear River to the confluence with the Sacramento River.

5.2.3.2 Data Limitations

Because the mesohabitat units generally are large, with a mean of 9.8 acres, the average depth does not represent the variability occurring throughout the unit. In each mesohabitat unit, there could be areas on the margins that are substantially shallower than the average depth attributed to the entire unit. Thus, water depth habitat suitability could differ near the margins or centers of mesohabitat units in which average water depth is reported to be unsuitable for different fish species and life stages.

5.2.3.3 Data Use

For each species and life stage, suitable minimum and maximum depth criteria were determined based on available literature. Due to the limitations associated with the use of an average depth criterion, the depth attribute only was used as an exclusionary criterion in the fish habitat classification. A habitat unit was excluded only if it had an average depth below the minimum or above the maximum established criteria for each species and life stage. For example, if the average depth of the mesohabitat unit was not deep enough to meet the minimum depth requirements of the fish habitat then the unit was excluded from the suitable habitat classification.

5.2.4 Instream Cover Complexity

5.2.4.1 Data Summary

Approximately 427 acres, or 14 percent of the existing habitat within the lower Feather River, lacked instream cover (Table 5.2-4). Mesohabitat units attributed as having low cover complexity comprised 250 acres of the lower Feather River, which accounted for approximately 8 percent of the existing habitat (Figure 5.2-16). Mesohabitat units attributed as having medium cover complexity comprised 276 acres, which accounted for approximately 9 percent of the existing habitat in the lower Feather River. Mesohabitat units attributed as having high instream cover complexity comprised 2041 acres, which accounted for approximately 68 percent of the existing habitat within the lower Feather River. Table 5.2-4 shows the instream cover complexity, presented by reach, in the lower Feather River.

Table 5.2-4. Instream cover complexity acreage by reach in the Feather River, from Thermalito Diversion Dam to the confluence with the Sacramento River.

	Thermalito Diversion Dam to Afterbay	Afterbay Outlet to Honcut Creek	Honcut Creek to Yuba River	Yuba River to Bear River	Bear River to Sacramento River
None	170	222	35	0	0
Low	103	97	28	16	6
Medium	1	222	34	19	0
High	1	9	490	827	714

Instream cover complexity displayed a spatial pattern of increasing complexity from upstream to downstream, with almost 100 percent of mesohabitat units in the most downstream reach of the lower Feather River having high instream cover complexity (Figure 5.2-17). Specifically, instream cover complexity appeared to increase rapidly with distance downstream from the confluence of the Feather River and Honcut Creek.

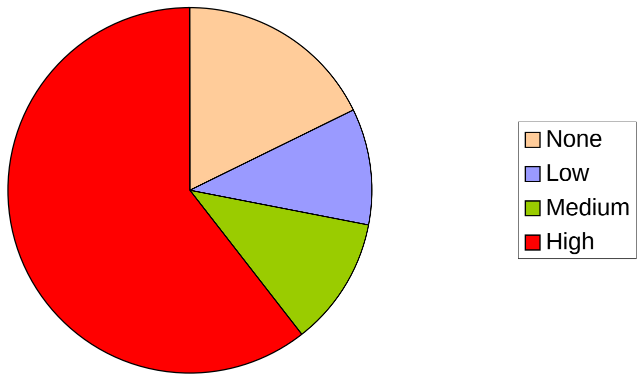


Figure 5.2-16. Proportions of instream cover complexity in the Feather River from the Thermalito Diversion Dam to the confluence with the Sacramento River.

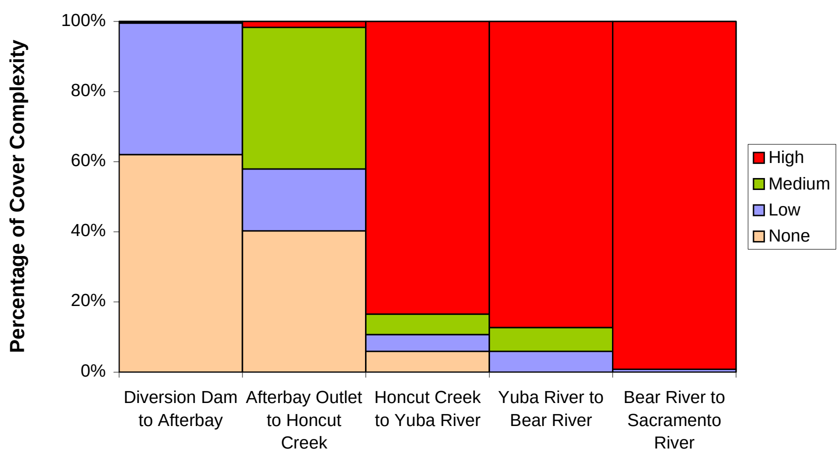


Figure 5.2-17. Proportions of instream cover complexity type by reach in the Feather River from the Thermalito Diversion Dam to the confluence with the Sacramento River.

Between the Thermalito Diversion Dam and the Thermalito Afterbay Outlet, approximately 170 acres did not exhibit any instream cover complexity, which represented approximately 62 percent of the reach. Approximately 103 acres, which represented 38 percent of the reach was classified as having low instream cover complexity. Mesohabitat units classified as having medium and high instream cover complexity covered areas of 0.5 acres and 0.7 acres, respectively, which accounted for approximately 0.2 percent and 0.3 percent, respectively of the reach (Figure 5.2-18).

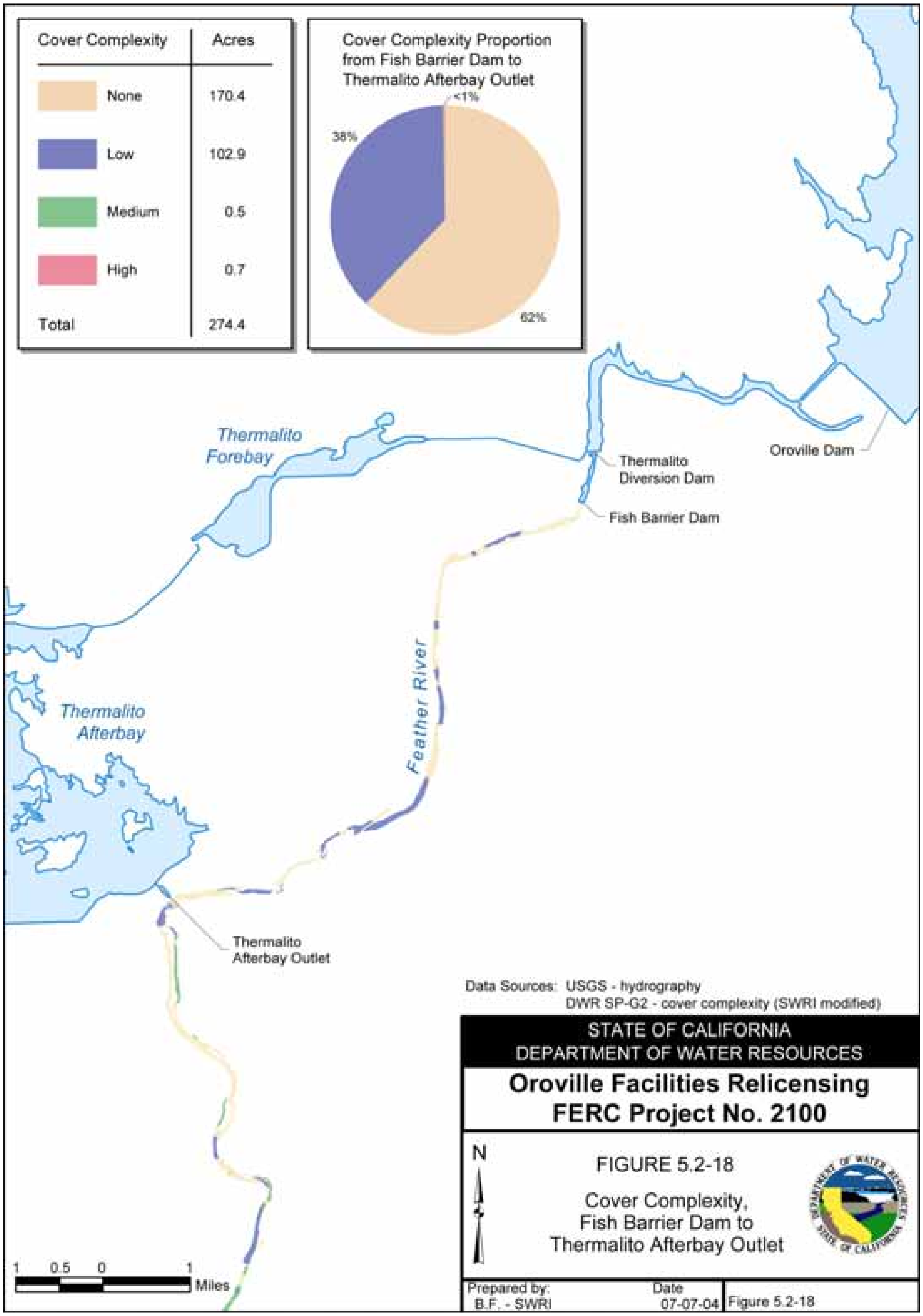


Figure 5.2-18. Instream cover complexity in the lower Feather River from the Diversion Dam to the Afterbay Outlet.

Between the Thermalito Afterbay Outlet and Honcut Creek, 222 acres did not exhibit any instream cover complexity, which represented approximately 40 percent of the reach. Approximately 97 acres, which represented 18 percent of the reach was classified as having low instream cover complexity. Mesohabitat units classified as having medium and high instream cover complexity covered areas of 222 and 9 acres, respectively, which accounted for approximately 40 percent and 2 percent of the reach (Figure 5.2-19).

Between Honcut Creek and the Yuba River, 35 acres did not exhibit any instream cover complexity, which represented approximately 6 percent of the reach. Approximately 28 acres, which represented 5 percent of the reach was classified as having low instream cover complexity. Mesohabitat units classified as having medium and high instream cover complexity covered areas of 34.2 and 490.3 acres, respectively, which accounted for approximately 6 percent and 84 percent of the reach (Figure 5.2-20).

Between the Yuba River and the Bear River, mesohabitat units classified as having low instream cover complexity occupied 16 acres, which represented approximately 2 percent of the reach. Mesohabitat units classified as having medium and high instream cover complexity covered areas of 19 and 827 acres, respectively, which accounted for approximately 2 percent and 96 percent of the reach (Figure 5.2-21).

Between the Bear River and the confluence with the Sacramento River, mesohabitat units classified as having low instream cover complexity occupied 6 acres, which represented approximately 1 percent of the reach. Highly complex habitats covered an area of 714 acres, which accounted for approximately 99 percent of the reach (Figure 5.2-22).

5.2.4.2 Data Limitations

The classification of instream cover complexity is somewhat subjective and was based on visual observations and the best professional judgment of DWR geologists collecting the data. The relative importance of instream cover complexity as a habitat component varies by fish species.

5.2.4.3 Data Use

Although instream cover complexity may be preferred as a habitat attribute by some species, instream cover complexity is not a requisite habitat component for any species. Because instream cover complexity is not required to qualify habitat for any species, it was not included in the fish habitat query or classification. However, the distribution of instream cover complexity could be useful for identifying or evaluating potential resource actions.

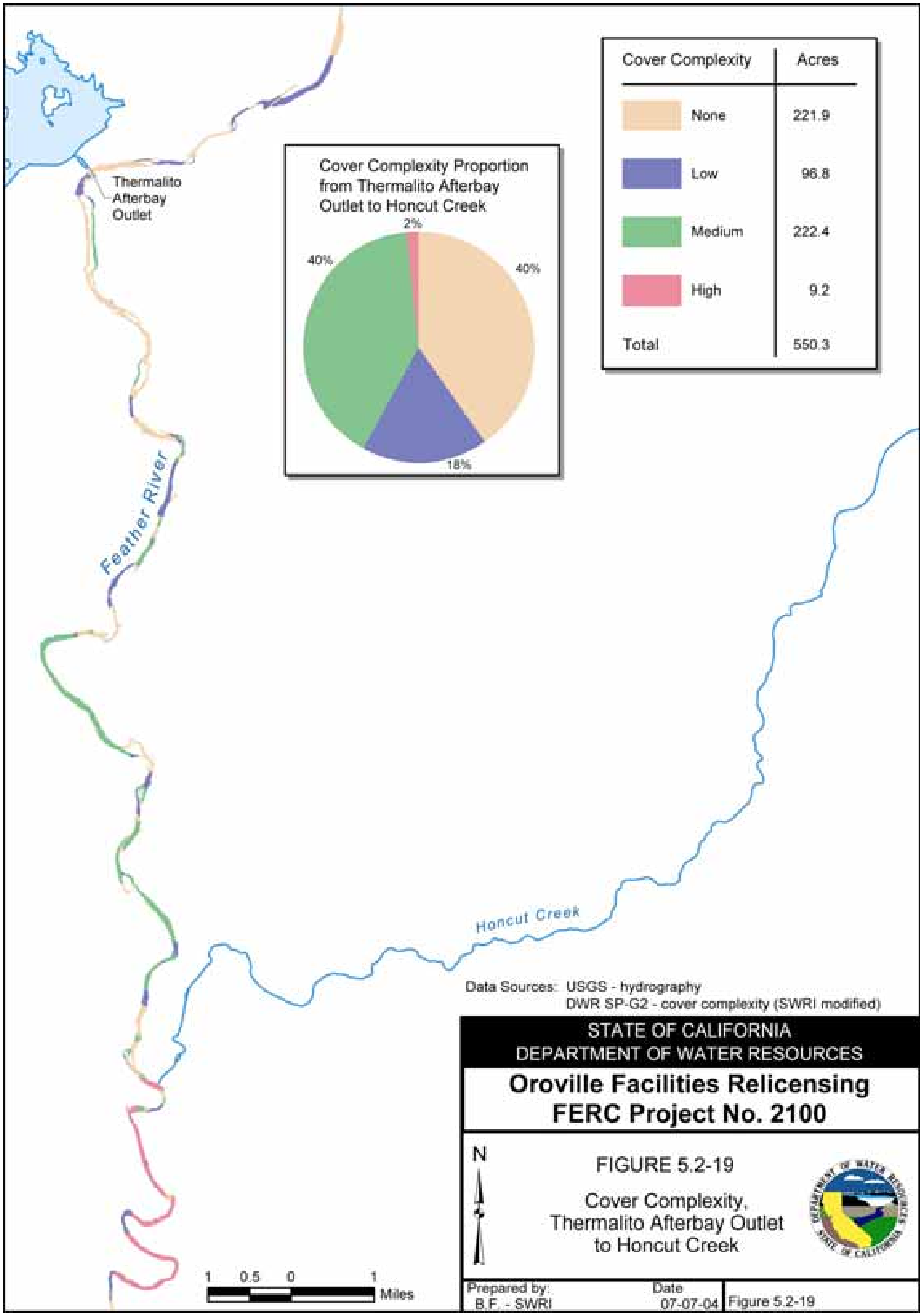


Figure 5.2-19. Instream cover complexity in the lower Feather River from the Afterbay Outlet to Honcut Creek.

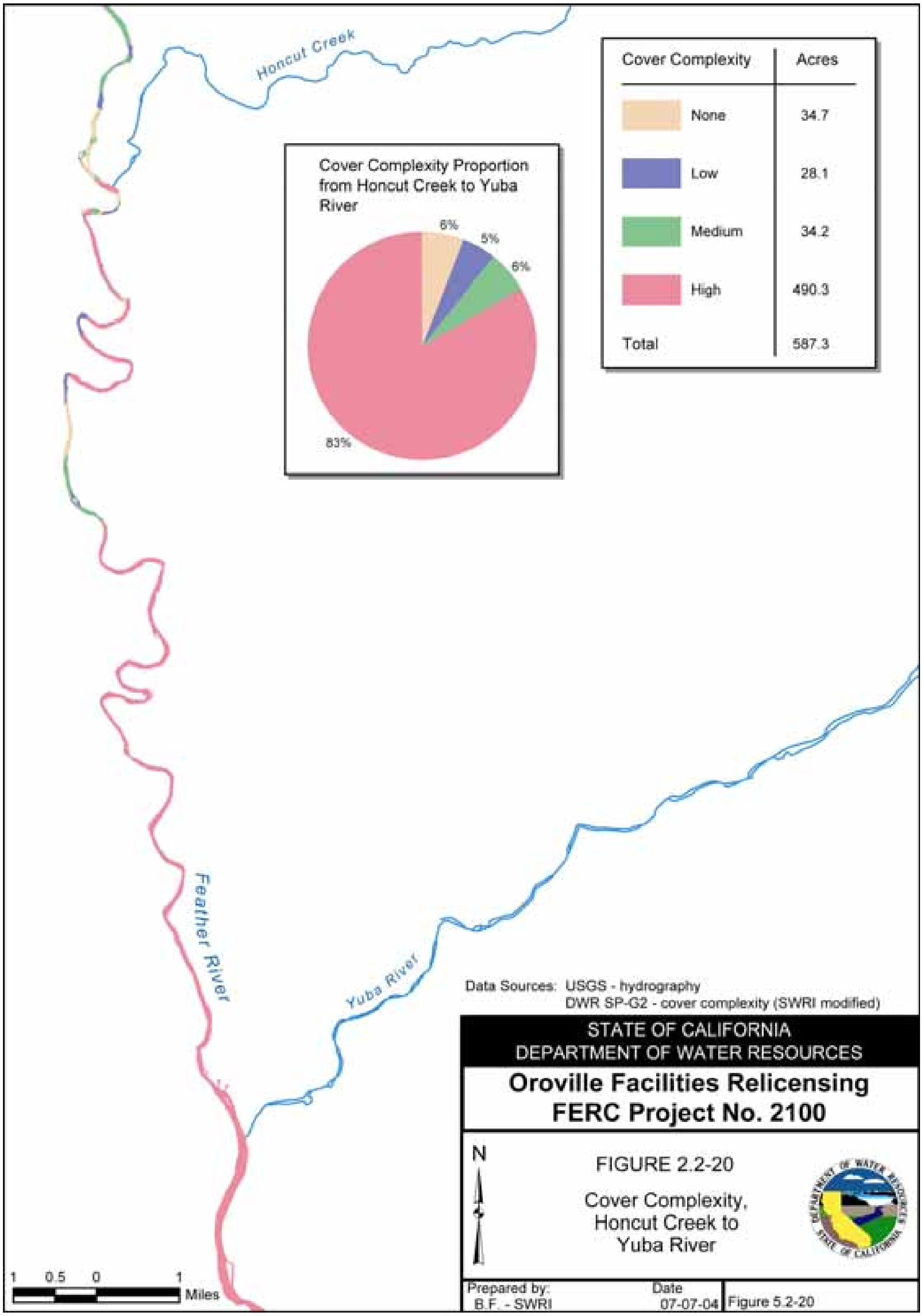


Figure 5.2-20. Instream cover complexity in the lower Feather River from Honcut Creek to the Yuba River.

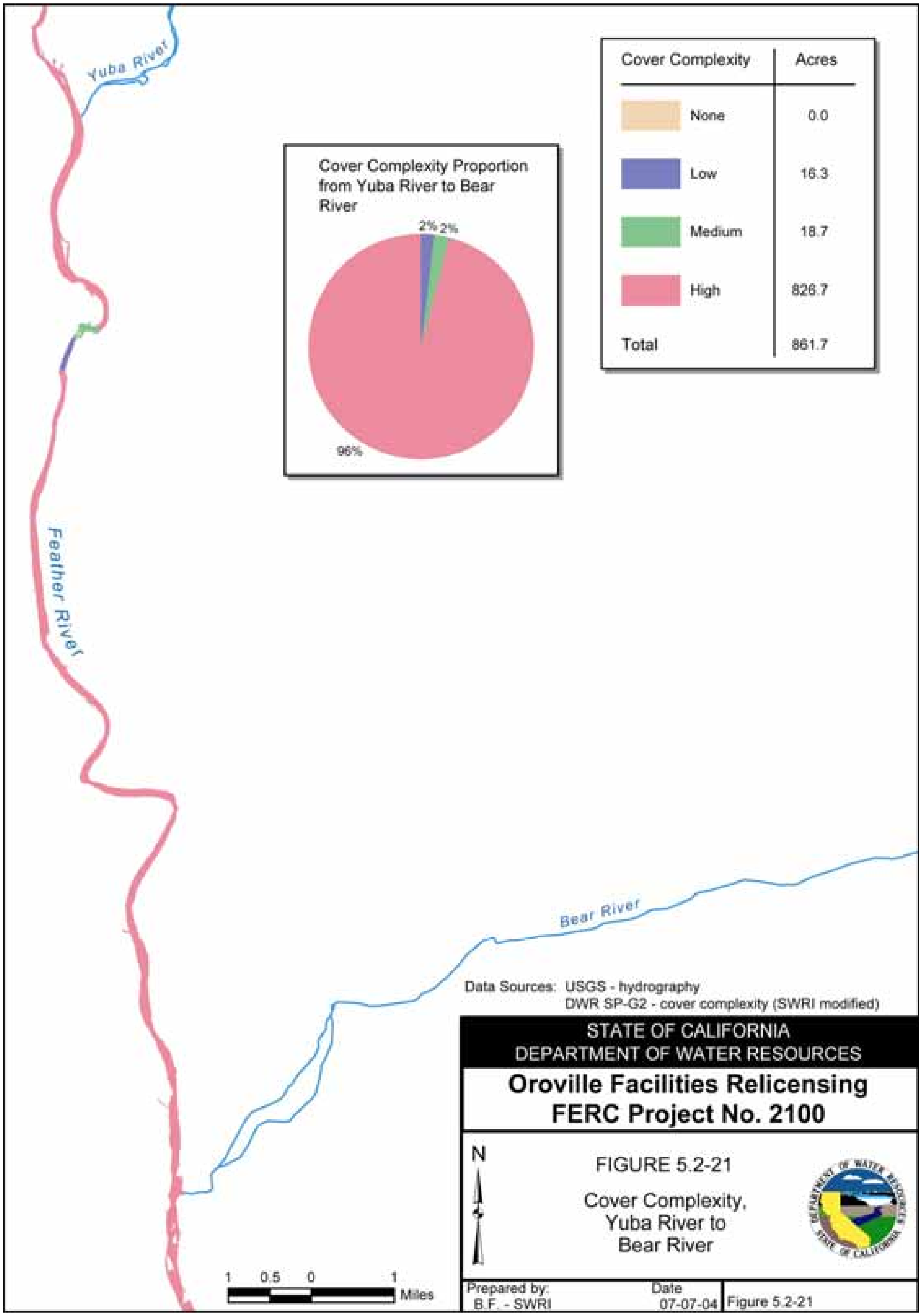


Figure 5.2-21. Instream cover complexity in the lower Feather River from the Yuba River to Bear River.